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ASTEROIDEA

By

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(Plates I–XXIII; Text-figs. A–M)

INTRODUCTION

THIS report deals with the sea stars collected by the ‘Discovery’, the ‘Discovery II’, and the ‘William Scoresby’ during the years 1925–36 in sub-Antarctic and Antarctic seas from the Falkland Island region to South Georgia, South Sandwich Group, South Orkneys, Antarctic Archipelago, and Ross Sea. A few hauls were made off Tristan da Cunha, Gough Island, Bouvet Island, and Marion Island. Certain species from Africa and elsewhere, which do not pertain to the Antarctic and sub-Antarctic faunas, have been listed separately.

Our knowledge of the Asteroid fauna of the sub-Antarctic and Antarctic seas is chiefly derived from the work of Koehler, based on the collections of the ‘Scotia’, the ‘Nimrod’, the ‘Pourquoi-Pas?’, the Australasian Antarctic Expedition, and the Swedish Antarctic Expedition. But much earlier the ‘Challenger’ occupied a number of stations between Prince Edward Islands and the Magellanic region, which included Kerguelen, Heard, and two stations (153, 156) near the Antarctic Circle at longitude $79\frac{1}{2}^{\circ}$ and $95\frac{1}{2}^{\circ}$ E. In the Challenger Report Sladen described numerous now familiar sub-Antarctic species and also the following Antarctic forms:

<i>Hyphalaster planus</i>	<i>P. stellifer</i>
<i>Lonchotaster forcipifer</i>	<i>Hymenaster nobilis</i>
<i>Mimastrella cognata</i> (olim <i>Mimaster</i>)	<i>H. formosus</i>
<i>Bathybiaster loripes obesus</i>	<i>H. sacculatus</i>
<i>Benthopecten antarcticus</i> (olim <i>Pararchaster</i>)	<i>H. caelatus</i>
<i>Acodontaster elongatus</i> (olim <i>Gnathaster</i>)	<i>H. crucifer</i>
<i>Chitonaster cataphractus</i>	<i>H. latebrosus</i>
<i>Perknaster fuscus</i>	<i>Freyella fragilissima</i>
<i>P. densus</i>	<i>Pedicellaster hypernotius</i>
<i>Porania antarctica glabra</i>	<i>Labidiaster annulatus</i>
<i>Solaster regularis subarcuatus</i>	<i>Smilasterias triremis</i>
<i>Pteraster rugatus</i>	

As these comprise around 20 per cent of the entire list of Antarctic sea stars, it will be seen that the ‘Challenger’ was in every sense a real pioneer.

Another important contribution is Perrier’s (1891) report on the collections made in 1882–3 by the ‘Mission Scientifique du Cap Horn’. This paper furnished a number of new sub-Antarctic species, still valid, and not a few nomenclatorial tangles. Only two of Perrier’s species, *Perknaster sladeni* and *Pteraster lebruni*, extend into Antarctic waters.

The Belgica collection reported by Hubert Ludwig (1903) added eleven new Antarctic species, of which three are synonymous with Challenger species.

The new species in the Discovery collection, some from regions already partly explored, indicate that we are yet a long way from having a complete picture of the Antarctic fauna. The following is a list of new forms, the exclusively sub-Antarctic being marked with an asterisk:

<i>Acodontaster elongatus granuliferus</i> forma ceramoideus*	<i>L. densus</i>
<i>Notioceramus anomalus</i>	<i>Paralophaster godefroyi meseres</i>
<i>Pergamaster synaptorus</i>	<i>Odinella nutrix</i>
<i>Cladaster analogus</i> *	<i>Anteliaster australis</i>
<i>Hippasteria falklandica</i> *	<i>Lethasterias australis</i> *
<i>Perknaster sladeni georgianus</i>	<i>Notasterias stolophora</i>
<i>Anseropoda antarctica</i>	<i>Psalidaster mordax</i> *
<i>Mirastrella biradialis</i>	<i>Lysasterias hemiora</i>
<i>Rhopiella koehleri</i>	<i>L. heteractis</i>
<i>Lophaster marionis</i> *	<i>Luidia heterozona</i> (Africa)

Notioceramus, *Mirastrella*, *Odinella*, and *Psalidaster* are new generic types, based upon new species, while *Rhopiella*, *Paralophaster*, and *Myoraster* are based upon species already known. A new subgenus *Apterodon* is instituted for a natural section of *Pteraster*, and *Euretaster* is a new name for the old genus *Retaster*, which by one of the accidents of nomenclature was really without a name. *Spoladaster* is a new generic name for *Cryaster brachyactis* H. L. Clark, which is not a *Cryaster* (i.e. *Perknaster*) but is related to *Tylaster* (Asteropidae).

It is still premature to analyse in detail the distribution of Antarctic species. The Discovery collection has materially enlarged, sometimes radically, the previously known range of included species. Some forms now believed to have a limited distribution are undoubtedly wide ranging. Certain characteristics of the Antarctic fauna may be noted.

There are no families strictly confined to the southern hemisphere, although the Ganeriidae are southern with two possible exceptions,¹ and the Odontasteridae are more numerous in genera and species in sub-Antarctic and Antarctic regions.

The following genera are Antarctic† or sub-Antarctic:*

ASTROPECTINIDAE	GANERIIDAE
<i>Mimastrella</i> †*	<i>Scotiaster</i> †
ODONTASTERIDAE	<i>Ganeria</i> †*
<i>Asterodon</i> *	<i>Cycethra</i> †*
<i>Acodontaster</i> †*	<i>Perknaster</i> †*
GONIASTERIDAE	ASTERINIDAE
<i>Notioceramus</i> †	<i>Kampylaster</i> †
<i>Pergamaster</i> †	<i>Mirastrella</i> †
<i>Chitonaster</i> †	

¹ *Leilaster* A. H. Clark, 1938, p. 1, pl. 1, figs. 1, 2. *Alcutiaster* A. H. Clark, *Proc. U.S. National Museum*, vol. LXXXVI, 1939, p. 497, pl. 57.

ECHINASTERIDAE	<i>Psalidaster</i> *
<i>Rhopiella</i> †	<i>Anasterias</i> *
SOLASTERIDAE	<i>Lysasterias</i> †
<i>Paralophaster</i> †	<i>Diplasterias</i> *†
<i>Myoraster</i> †	<i>Adelasterias</i> †
<i>Cuenotaster</i> †	<i>Cryptasterias</i> *†
BRISINGIDAE	<i>Saliasterias</i> †
<i>Odinella</i> †	<i>Neosmilaster</i> *†
<i>Belgicella</i> †	<i>Smilasterias</i> *†
ASTERIIDAE	<i>Eremasterias</i> *
<i>Labidiaster</i> *†	<i>Cosmasterias</i> *†
<i>Notasterias</i> †	<i>Granaster</i> †
	<i>Calvasterias</i> *

The species which give “character” to the Antarctic fauna either by their surpassing size* or frequency† of occurrence are the following:

<i>Leptychaster accrescens</i> *	<i>Perknaster fuscus antarcticus</i> *†
<i>L. flexuosus</i> *	<i>P. charcoti</i> *
<i>L. magnificus</i> *	<i>P. aurorae</i> *
<i>Bathymbiaster loripes obesus</i> *†	<i>Porania antarctica glabra</i> †
<i>Psilaster charcoti</i> *†	<i>Myoraster antarcticus</i> *†
<i>Luidiaster gerlachei</i> *	<i>Cuenotaster involutus</i>
<i>Odontaster meridionalis</i> †	<i>Labidiaster annulatus</i> *†
<i>O. validus</i> †	<i>Lysasterias perrieri</i> *†
<i>Acodontaster elongatus</i> *	<i>Diplasterias brucei</i> *†
<i>A. conspicuus</i> *	<i>Granaster nutrix</i> †
<i>A. hodgsoni</i> *	

This list of course omits many species which are equally characteristic or unusual but which do not bulk large in collections. Such are the other species of genera peculiar to the Antarctic listed above, as well as the rare *Notioceramus*, *Pergamaster*, *Chitonaster*, *Kampylaster*, *Mirastrella*, *Rhopiella*, *Paralophaster* and *Odinella*.

The last is a very unusual new type of Brisingidae, a family not well represented in southern seas. It has “evolved” an entirely new type of marsupium for the care of developing eggs—the only known case of “brooding” in the family.

The brooding of paedophoric habit of certain sea stars of the cold waters of both northern and southern hemispheres has long been known. Ludwig in 1903 (p. 56) published a list of references to eleven Antarctic and sub-Antarctic species.

It is likely that all species of *Pteraster*, *Euretaster*, *Diplopteraster* and *Hymenaster* brood their young in the supradorsal chamber. The habit is probably widespread in *Leptychaster* and *Henricia*, as well as in all genera having large eggs and gonoducts which open ventrally. Eggs, embryos, or young have been observed in the brood cavity of the following southern genera: *Kampylaster*, *Rhopiella*, *Odinella*, *Anasterias*, *Lysasterias*, *Diplasterias*, *Cryptasterias*,¹ *Neosmilaster*, *Granaster*. The following genera are probably

¹ Koehler (1906, p. 21) states that several specimens “sont fixés dans l’attitude incubatrice, le disque relevé et la base des bras rapprochée; mais aucun d’eux n’est en gestation”. The eggs of *C. turqueti* are few and unusually large.

paedophoric: *Mirastrella*, *Anteliaster*, *Psolidaster*; but they have not as yet been observed carrying embryos or young.

Koehler published in 1912 (pp. 252-5) a most useful list of Antarctic and sub-Antarctic sea stars in which sixty-seven species are cited. In the following revised list there are 114 species, even though fifteen names of Koehler's table do not appear in my list. This is reduced to ten, however, by the inclusion of five of Koehler's sub-Antarctic species in my list. Numerous new species, of course, were added by Koehler subsequent to 1912.

LIST OF ANTARCTIC SEA STARS WITH BATHYMETRIC RANGE.
SPECIES PRECEDED BY ASTERISK ARE ALSO SUB-ANTARCTIC

- | | |
|---|--|
| <i>Hyphalaster scotiae</i> Koehler, 2580 m. | <i>P. charcoti</i> (Koehler), 0-235 m. |
| <i>H. planus</i> Sladen, 3568 m. | <i>P. aurorae</i> (Koehler), 18-310 m. |
| <i>Lonchotaster forcipifer</i> Sladen, 2568-3615 m. | <i>P. aurantiacus</i> Koehler, 92-254 m. |
| <i>Leptychaster kerguelensis</i> Smith, 18-384 m. | <i>Anseropoda antarctica</i> Fisher, 342 m. |
| <i>L. flexuosus</i> Koehler, 351-581 m. | <i>Kampylaster incurvatus</i> Koehler, 93-351 m. |
| <i>L. accrescens</i> Koehler, 97-608 m. | <i>Mirastrella biradialis</i> Fisher, 177-342 m. |
| <i>L. magnificus</i> (Koehler), 5-203 m. | <i>Porania antarctica glabra</i> Sladen, 15-567 m. |
| * <i>Mimastrella cognata</i> (Sladen), 450-2424 m. | * <i>Echinaster spinulifer</i> E. A. Smith, ¹ 0-91 m. |
| <i>Bathybiaster loripes obesus</i> Sladen, 18-420 m. | <i>Rhopiella koehleri</i> Fisher, 93-335 m. |
| <i>Psilaster charcoti</i> (Koehler), 0-2424 m. | <i>R. hirsuta</i> (Koehler), 276-647 m. |
| <i>Dytaster felix</i> Koehler, 2580 m. | <i>R. pterasteroides</i> (Koehler), 655 m. |
| <i>Luidiaster gerlachei</i> (Ludwig), 160-810 m. | <i>R. smilax</i> (Koehler), 191-581 m. |
| <i>L. antarcticus</i> (Koehler), 3238 m. (<i>Marcelaster antarcticus</i>) | <i>R. smithi</i> (Ludwig), 450 m. |
| <i>Benthopecten antarcticus</i> (Sladen), 3065 m. | * <i>Henricia pagenstecheri</i> (Studer), 18-250 m. |
| <i>Odontaster meridionalis</i> (Smith), 0-647 m. | <i>H. pagenstecheri parva</i> (Koehler), 191-610 m. |
| <i>O. validus</i> Koehler, 0-653 m. | * <i>H. diffidens</i> (Koehler), 75-463 m. |
| <i>Acodontaster elongatus</i> (Sladen), 108-647 m. | * <i>Lophaster stellans</i> Sladen, 450 m. ² |
| * <i>A. conspicuus</i> (Koehler), 24-647 m. | <i>L. gaini</i> Koehler, 191-732 m. |
| <i>A. marginatus</i> (Koehler), 250 m. | <i>L. densus</i> Fisher, 200-610 m. |
| <i>A. waitei</i> (Koehler), 160-647 m. | <i>Paralophaster godefroyi</i> (Koehler), 250-400 m. |
| <i>A. hodgsoni</i> (Bell), 3-204 m. | <i>P. godefroyi meseres</i> Fisher, 567 m. |
| <i>Notioceramus anomalus</i> Fisher, 342 m. | <i>P. asperatus</i> Koehler, 191 m. |
| <i>Pergamaster incertus</i> (Bell), 96-3111 m. | <i>P. lorioli</i> Koehler, 4575 m. |
| <i>P. synaptorus</i> Fisher, 342 m. | <i>Solaster regularis subarcuatus</i> Sladen, 183-500 m. |
| <i>Chitonaster cataphractus</i> Sladen, 3614 m. | <i>Myraster antarcticus</i> (Koehler), 99-750 m. |
| <i>C. johannae</i> Koehler, 3248 m. | <i>M. ? tenuis</i> ³ (Koehler), 191 m. |
| <i>Scotiaster inornatus</i> Koehler, 3848 m. | <i>Cuenotaster involutus</i> (Koehler), 60-700 m. |
| <i>Ganeria attenuata</i> Koehler, 3248 m. | <i>Remaster gourdoni</i> Koehler, 10-342 m. |
| * <i>Cycethra verrucosa</i> (Philippi), 60-342 m. | <i>Peribolaster macleani</i> Koehler, 191-581 m. |
| * <i>Perknaster fuscus</i> Sladen, 46-138 m. | * <i>Pteraster lebrunii</i> Perrier, 74-450 m. |
| <i>P. fuscus antarcticus</i> (Koehler), 11-335 m. | <i>P. aculeatus</i> Koehler, 614 m. |
| * <i>P. densus</i> Sladen, 101-233 m. | <i>P. rugatus</i> Sladen, 274 m. |
| * <i>P. sladeni</i> (Perrier), 199-500 m. | * <i>P. stellifer</i> Sladen, 79-655 m. |
| <i>P. sladeni gergianus</i> Fisher, 120-204 m. | <i>Hymenaster nobilis</i> Sladen, ⁴ 3294 m. |
| | <i>H. formosus</i> Sladen, ⁴ 3294 m. |

¹ A Kerguelen species recorded from South Georgia, 91 m., by G. A. Smith, 1923, p. 368.

² The Antarctic specimens recorded by Ludwig (1903, p. 27). The species is typically sub-Antarctic.

³ May belong in *Lophaster*.

⁴ Challenger St. 158, 50° 1' S, 123° 4' E, bottom temperature 33.5° F.

H. sacculatus Sladen,¹ 3294 m.
H. caelatus Sladen,¹ 3294 m.
H. crucifer Sladen,¹ 3294 m.
H. latebrosus Sladen,² 3568 m.
H. perspicuus Ludwig, 450 m.
H. campanulatus Koehler, 2580 m.
H. edax Koehler, 3248 m.
H. fucatus Koehler, 2580 m.
H. densus Koehler, 4794 m.
Odinella nutrix Fisher, 120–545 m.
Belgicella racovitzana Ludwig, 2580–2800 m.
Freyella fragilissima Sladen, 2515–3615 m.
F. giardi Koehler, 4575 m.
**Pedicellaster hypernotius* Sladen, 93–450 m.
P. formatus Koehler, 219 m.
Antelaster australis Fisher, 177–260 m.
Labidiaster annulatus Sladen, 93–440 m.
Sclerasterias candicans (Ludwig), 450–560 m.
Notasterias armata Koehler, 30–647 m.
N. stolophora Fisher, 247 m.
N. bongraini (Koehler), 109–830 m.
N. pedicellaris (Koehler), 2580 m.
N. haswelli Koehler, 109–647 m.

Lysasterias perrieri (Studer), 0–647 m.
L. heteractis Fisher, 342 m.
L. adeliae (Koehler), 22–335 m.
L. joffrei (Koehler), 351–810 m.
L. chirophora (Ludwig), 450–560 m.
L. hemiora Fisher, 70 m.
L. lactea (Ludwig), 450 m.
L. belgicae (Ludwig), 560 m.
Adelasterias papillosa (Koehler), 0–6 m.
**Diplasterias brandti* (Bell), 50–300 m.
**D. meridionalis* (Perrier), 0–234 m.
D. brucei (Koehler), 0–581 m.
D. fochi (Koehler), 109–732 m.
D. octoradiata (Studer),³ 8–55 m.
D. radiata (Koehler),⁴ 160–177 m.
Cryptasterias turqueti (Koehler), 0–36 m.
Saliasterias brachiata Koehler, 647 m.
Neosmilaster georgianus (Studer), 0–335 m.
**Neosmilaster steineni* (Studer), 99–160 m.
Smilasterias tiremis Sladen, 93–335 m.
**Cosmasterias lurida* (Philippi), 0–636 m.
Grammaster nutrix (Studer), 0–250 m.

The Discovery collection has afforded an opportunity to revise certain groups, notably the Odontasteridae and *Perknaster*, with the result that the status of a number of genera and of two higher groups is altered. I am unable to see the utility of retaining the following:

Priamaster Koehler = *Leptychaster* Smith
Priamasterinae Fisher
Ripaster Koehler = *Psilaster* Sladen
Marcelaster Koehler = *Luidiaster* Studer
Heuresaster Bell = *Acodontaster* Verrill
Pseudontaster Koehler = *Acodontaster*
Tridontaster Koehler = *Acodontaster*
Metadontaster Koehler = *Acodontaster*
Peridontaster Koehler = *Odontaster* Verrill
Epidontaster Koehler = *Odontaster*
Glabraster A. H. Clark = *Porania* Gray
Cryaster Koehler = *Perknaster* Sladen
Cryasteridae Fisher = *Ganeriidae* pars.
Labidiastrella Verrill = *Labidiaster* Lütken

Autasterias Koehler = *Notasterias* Koehler
Notasteriinae Fisher = *Cosinasteriinae* pars
Sporasterias Perrier = *Anasterias* Perrier
Parastichaster Koehler = *Anasterias* Perrier
Kalyptasterias Koehler = *Anasterias* Perrier
Anasterias Ludwig nec Perrier = *Lysasterias* Fisher
Paedasterias Verrill = *Lysasterias*
Podasterias Perrier = *Diplasterias* Perrier
Kochleraster Fisher = *Diplasterias*
Bathyasterias Fisher (subgenus) = *Diplasterias*
Ctenasterias Koehler nec Verrill = *Neosmilaster*
 Fisher
Hemiasterias Verrill = *Granaster* Perrier
Parasterina Fisher = *Nepanthia* Gray

¹ Challenger St. 158, 50° 1' S, 123° 4' E, bottom temperature 33.5° F.

² Challenger St. 157, 53° 55' S, 108° 35' E, bottom temperature 32.1° F.

³ South Georgia only.

⁴ Shag Rocks (South Georgia) only.

ASTEROIDEA

Family GONIOPECTINIDAE Verrill, emended¹Genus *Ctenodiscus* Müller & Troschel*Ctenodiscus australis* Lütken

Ctenodiscus australis Lütken, *Vidensk. Medd. naturh. Foren. i. Kjøbenhavn*, 1871, p. 288.—Sladen, 1889, p. 172, pl. 30, figs. 1–6.—Perrier, 1891, p. 142.

- St. WS 73. 51° 01' S, 58° 54' W, 121 m., fine dark sand, 8 specimens.
 St. WS 75. 51° 01' 30" S, 60° 31' W, 72 m., 1 specimen.
 St. WS 79. 51° 01' 30" S, 64° 59' 30" W, 131–132 m., fine dark sand, 1 specimen.
 St. WS 80. 50° 57' S, 63° 37' 30" W, 152–156, fine dark sand, 1 specimen.
 St. WS 81. 8 miles north-west of North Island, West Falkland Island, 81–82 m., sand, 3 specimens.
 St. WS 82. 51° 30' S, 61° 15' W, 140–144 m., 1 specimen.
 St. WS 92. 51° 58' 30" S, 65° 01' W, 145–143 m., 9 specimens.
 St. WS 94. 50° 11' 15" S, 64° 57' 45" S, 110–116 m., 1 specimen.
 St. WS 98. 49° 54' 15" S, 60° 35' 30" W, 171–173 m., 12 specimens.
 St. WS 108. East of Punta Mendanosa, Argentina, 48° 30' 45" S, 63° 33' 45" W, 118–120 m., 1 specimen.
 St. WS 109. 50° 18' 48" S, 58° 28' 30" W, 145 m., fine dark sand, 1 specimen.
 St. WS 210. 50° 17' S, 60° 06' W, 161 m., green sand, 8 specimens.
 St. WS 211. 50° 17' S, 60° 06' W, 174 m., 2 specimens.
 St. WS 212. 49° 22' S, 60° 10' W, 242–249 m., 1 specimen.
 St. WS 214. 48° 25' S, 60° 40' W, 208 m., 14 specimens.
 St. WS 216. East of Golfo San Jorge, Argentina, 47° 37' S, 60° 50' W, 219–133 m., find sand, 1 specimen.
 St. WS 233. 49° 25' S, 59° 45' W, 185–175 m., fine green sand, 2 specimens.
 St. WS 234. 48° 52' S, 60° 25' W, 195–207 m., 2 specimens.
 St. WS 236. East of Golfo San Jorge, Argentina, 46° 55' S, 60° 40' W, 272–300 m., 1 specimen.
 St. WS 243. 51° 06' S, 64° 30' W, 144–141 m., coarse dark sand, 9 specimens.
 St. WS 244. 52° S, 62° 40' W, 253–247 m., fine dark sand and mud, 2 specimens.
 St. WS 245. 52° 36' S, 63° 40' W, 304–290 m., 1 specimen.
 St. WS 249. 52° 10' S, 57° 30' W, 166 m., fine brown and green sand, shells, stone, 9 specimens.
 St. WS 756. 50° 54' 39" S, 59° 58' W, 118 m., 1 specimen.
 St. WS 764 B. Off Argentina, 44° 38' S, 61° 58' W, 106 m., 2 specimens.
 St. WS 766. Off Argentina, 44° 58' S, 60° 05' W, 545 m., 1 specimen.
 St. WS 773. East of Golfo San Jorge, Argentina, 47° 28' S, 60° 51' W, 291 m., 2 specimens.
 St. WS 774. 47° 08' S, 62° 02' W, 139 m., dark green sand and mud, 3 specimens.
 St. WS 775. 46° 44' 45" S, 63° 33' W, 115–110 m., gravel, fine grey sand, 2 specimens.
 St. WS 782 A. 50° 29½' S, 58° 23¾' W, 141–146 m., 19 specimens.
 St. WS 783. 50° 03' S, 60° 10' W, 155–159 m., 2 specimens.
 St. WS 784. 49° 48' S, 61° 05' W, 164–170 m., dark green sand, 2 specimens.
 St. WS 785 C. 49° 23' 45" S, 62° 41' 15" W, 150–146 m., dark green sand, 1 specimen.
 St. WS 790 B. Off Golfo San Jorge, Argentina, 45° 31' 30" S, 63° 31' W, 99–101 m., green grey sand, 3 specimens.

¹ See Fisher (1919, p. 43) for discussion of relationships of *Ctenodiscus*.

- St. WS 791. $45^{\circ} 38' S$, $62^{\circ} 57' W$, 97–96 m., 1 specimen.
 St. WS 792. $45^{\circ} 49' 30'' S$, $62^{\circ} 20' 15'' W$, 102–106 m., dark green sand, 1 specimen.
 St. WS 793. $45^{\circ} 53' S$, $61^{\circ} 35' W$, 108–111 m., 2 specimens.
 St. WS 795. $46^{\circ} 14' S$, $60^{\circ} 24' W$, 157–161 m., 1 specimen.
 St. WS 796. $47^{\circ} 49' 37'' S$, $63^{\circ} 42\frac{1}{2}' W$, 106–113 m., 1 specimen.
 St. WS 797. $47^{\circ} 45' 18'' S$, $64^{\circ} 10' 30'' W$, 115–112 m., stones, 2 specimens.
 St. WS 801. $48^{\circ} 26\frac{1}{4}' S$, $61^{\circ} 28' W$, 165 m., 3 specimens.
 St. WS 805. $50^{\circ} 10\frac{1}{4}' S$, $63^{\circ} 29' W$, 148 m., 2 specimens.
 St. WS 809. East of Porto Santa Cruz, Argentina, $49^{\circ} 28\frac{1}{4}' S$, $66^{\circ} 29' W$, 107–104 m., 1 specimen.
 St. WS 817. $52^{\circ} 23' S$, $64^{\circ} 19' W$, 191–202 m., 3 specimens.
 St. WS 818A. $52^{\circ} 31\frac{1}{4}' S$, $63^{\circ} 25' W$, 272–278 m., 1 specimen.
 St. WS 819A. $52^{\circ} 41' 52'' S$, $62^{\circ} 39' 30'' W$, 312–329 m., 1 specimen.
 St. WS 839. $53^{\circ} 30' S$, $63^{\circ} 29' W$, 403–434 m., 1 specimen.

In the considerable series of specimens of all sizes there is much more uniformity of structure than I found in north Pacific examples of *C. crispatus*,¹ of which I had 883 specimens. Owing to the great variability among these, and perhaps somewhat influenced by Perrier's remarks,² I questioned the validity of *C. australis*, of which I had no adequate material. It now seems to me possible that Perrier was not dealing with typical *australis* but with variants arising from a mingling of *australis* and *procurator*, as his specimens were taken, with the exception of one locality off Argentina, in the Magellan-Cape Horn region (Beagle Canal, Franklin Canal, Murray Narrows). There is no great difficulty in distinguishing typical *australis* from north Atlantic material.

As Sladen (1889) has already pointed out, *australis* can be distinguished from *procurator* by its constantly larger paxillae and fewer marginal plates. I have only two specimens of *procurator*, from 122 fathoms off Chile: R is 22 mm. and there are 17 and 18 marginal plates, while in comparable examples of *australis* there are 12 and 13. The largest paxillae of the Chilean specimens have 6 or 7 spinelets (none in centre) and are therefore similar to the type of *procurator*. In *australis* the largest paxillae (in interradial triangles) commonly have 9–11 peripheral and upward of 5–8 central spinelets, all longer and stouter than in *procurator*. Naturally there is a big contrast in the size of the paxillae.

While *australis* looks more like *crispatus* than either, one resembles *procurator*. I believe the first two are nevertheless distinct in the sense that any two nearly related species of sea stars are distinct. Why two recognizable species of *Ctenodiscus* occupy the two sides of southern South America is a puzzle. *Ctenodiscus* is very widely distributed in the north and eastern Pacific, namely, from the Sea of Japan to the Bering Sea and the Arctic Ocean, south along the American coast to central California, Gulf of California, and Gulf of Panama. There are no records south of Panama until the home of *procurator*, off Chile, is reached.

However, it may be recalled that *Ceramaster patagonicus* is found on the Alaskan coast and in the southern Bering Sea. *Odontaster crassus* of California is closely similar to *O. grayi* of the Falkland-Magellan region. The relatively gigantic *Pedicellaster magister*

¹ Fisher, 1911, p. 32.

² Perrier, 1891, pp. 143, 144.

Fisher¹ of Alaska is more nearly like *P. hypernotius* Sladen of the Antarctic than it is like *P. typicus* of the north Atlantic and adjacent Arctic.

It seems to me probable that a *Ctenodiscus* species similar to *procurator* was formerly common to southern South America and Alaska, that later *C. crispatus* invaded Bering Sea from the Arctic and extended its range southward, as it has done on the Atlantic coast; that there has been a commingling of two originally distinct forms in the north Pacific, resulting in the highly unstable *Ctenodiscus* found there to-day.

C. australis would be the south Atlantic equivalent of a relatively more stable north Atlantic stock. It is worth noting that *C. crispatus* is a true high Arctic species which extends into boreal waters, whereas neither *C. australis* nor *C. procurator* has been taken in Antarctic waters.

The largest specimens of *australis* have R 26 mm., r 14 mm., and 13 marginal plates in each series. The largest north Pacific example of *crispatus* has R 40 mm. and 17-18 marginal plates; but specimens nearly as large (R 29-35 mm.) have only 11-13 marginals.

YOUNG. At St. WS 212 a series of 9 young was taken. The 5 smallest, 1.7 mm. in diameter, are pentagonal, with relatively enormous terminal plates which occupy most of the periphery. Each plate carries a dorsal spike-like sharp spine, nearly as long as the minor radius, and 2 or 3 shorter terminal ones. There are 2 short marginal pairs of plates and 3 rather rudimentary cribriform organs. The median is interrarial and the others are between the border of terminal plate and each marginal plate. These marginals encroach upon the paxillar area about $\frac{1}{2}$ r; and centre of disk is raised into a low cone. The close-set rudimentary abactinal plates have 1-3 tiny spinelets. There are 3 pairs of relatively large tube feet on which the tip is no better developed than in the adult. Each mouth angle has a prominent pair of plates with 4 or 5 short spinelets on the furrow border (sometimes 1 occupies apex of mouth angle), and 1 prominent suboral on outer part of plate. Adambulacral plates 2, the inner with 2, the outer with 1 spinelet.

The largest specimen of the series has R 2.3 mm. and r 1.7 mm., a stellate contour, and 5 cribriform organs on each side (2 supero- and 2 inferomarginals to each ray). The largest paxillae have 4 or 5 short spinelets, while the madreporite is covered with 14 spinelets and looks like a large paxilla. Tube feet, 5 pairs; adambulacrals 4, the first with 4, the others with 3 short sharp spinelets; 2 actinal interrarial plates on each interradius.

FOOD. *Ctenodiscus* evidently lives nearly covered by the soft mud or muddy sand of its characteristic habitat, the conical elevation of centre of disk rising above the surface as in the case of *Astropecten*. The cribriform channels of the marginal and actinal surfaces are contrivances for maintenance of currents of water to and from the actinal surface by means of the ectodermal cilia.

If food is conveyed to the mouth by these cilia, it is not the principal source, since mud is ingested in large quantities along with whatever contained objects are small enough to pass through the mouth. Sometimes the abactinal surface is convex from an overstuffed stomach, as in the case of a specimen from St. WS 805. In the fine sand and muddy debris, in which simple sponge spicules are numerous, are 3 pebbles, the largest

¹ Fisher, 1928, pp. 35, 36.

6 mm. in diameter, fragments of an encrusting bryozoan, a gastropod shell, delicate membranous worm tubes, and a sea-urchin spine, possibly *Austrocidaris canaliculata* (A. Agassiz). Treatment of the mud with sodium hypochlorite indicates a large percentage of organic material.

Family ASTROPECTINIDAE Gray

Genus *Leptychaster* Smith

Leptychaster Smith, *Ann. Mag. Nat. Hist.*, Ser. 4, XVII, 1876, p. 110. Type *L. kerguelensis* Smith.

Leptoptychaster Smith, *Philos. Trans. Roy. Soc.*, Zool. Kerguelen Island, CLXVIII, 1879, p. 278.

Emendation of *Leptychaster*.

Parastropecten Ludwig, *Mem. Mus. Comp. Zool.*, XXXII, 1905, p. 76. Type *P. inermis* Ludwig.

Glyphaster Verrill, *Amer. Nat.*, XLIII, 1909, p. 553. Type *Leptychaster anomalus* Fisher.—1914,

p. 327.

Priamaster Koehler, 1912, p. 92. Type *P. magnificus* Koehler.

Trophodiscus Fisher, 1917, p. 367. Type *T. almus* Fisher.

New information on the structure of *Leptychaster kerguelensis* makes it desirable to review the north Pacific species referred to *Leptychaster*. These are *L. arcticus* (found also in the north Atlantic), *L. pacificus* Fisher, *L. propinquus* Fisher, *L. anomalus* Fisher.¹ When the accounts of these species were written no information was available on the distribution of the gonads in the type of the genus, nor had I seen a specimen of *kerguelensis*. In the description of *Trophodiscus almus*, the distribution of gonads in 4 species of *Leptychaster* is stated as follows (Fisher, 1917a, p. 371): "In four species of the genus *Leptychaster* which I have been able to examine, the testes differ in distribution from the ovaries. In *L. arcticus*, *L. pacificus*, *L. propinquus* and *L. anomalus* (the last three being North Pacific species) the ovaries are in a single tuft close to the inter-radial septum—a pair, thus, in each interbrachium. In some specimens the branches may extend far along the ray, but they are attached in only one place, as stated above. In the male the gonads form a series of independent tufts of tubules, parallel with the margin, and distributed for a third to nearly a half the length of ray, according to the size of the specimen. The distribution of the testes in the above species of *Leptychaster* is therefore similar to the distribution of both ovaries and testes in *Trophodiscus*, *Dipsacaster*, *Ctenopleura*, *Tethyaster*, *Thrissacanthias*, and other genera. This condition of the gonads is apparently characteristic of the genus *Leptychaster*, although of course it will doubtless be found to be true of other genera. The reason I did not discover this when working up my North Pacific Asteroidea, Part I, was the fact that I dissected then only a single example of each species, which happened in each case to be a female. Recently, at the United States Museum, I found 'serial gonads' in a specimen of *L. arcticus* from station 21, Cashes Ledge. A specimen from station 4779 (North Pacific) has serial gonads and is a *male*, while a *female* from station 5047 has strictly interrational, non-serial, gonads.

¹ These species are described and figured in Fisher (1911), where a definition of *Leptychaster* is given, based on the northern species only. The statement in regard to distribution of gonads is erroneous, as explained below.

"This arrangement of the gonads holds true in all specimens examined, namely:

"*Leptychaster propinquus*, 2 males and 3 females; station 4788.

"*L. anomalus*, 1 male, station 4233; 1 female, station 4280.

"*L. pacificus*, 1 male, station 3223; 2 females, station 2862."

I have ascertained that in *L. kerguelensis* the ovaries are not as in the northern species, but are serially arranged close to the marginal plates; and that *L. magnificus* and *L. accrescens* also have both ovaries and testes in series (although not close to marginal plates).

The northern forms have not been observed to brood their young. They differ also in having somewhat longer, less compressed adambulacral plates with a curved furrow margin, rather than the sharply angular one of *kerguelensis*, *accrescens*, and *magnificus*. The furrow armature of these three southern species is composed of 3 spines which generally stand upright in a co-ordinated group. In the northern forms, even in *arcticus*, it is a comb of spines (3-6 in different species, usually 3 or 4) followed by 3 longiseries of 3-5 similar spines (Fisher, 1911, pl. 5, figs. 1, 2). The southern forms have relatively larger tube feet.

In the specimen of *L. kerguelensis* the papulae are confined to the margin of the abactinal area, where the plates have very short lobes. Elsewhere the plates are roundish. But in *accrescens* and *magnificus* the papulae extend completely across ray and all the plates are stellate or strongly 6- or 5-lobed (in *magnificus* reduced to 4 near margin of area).

I have discussed (1911, pp. 52, 53) the difficulty of distributing the north Pacific species between *Glyphaster* Verrill (= *Parastropecten* Ludwig) and *Leptychaster*. Verrill (1914, p. 327) did this, but his diagnosis of *Glyphaster* is not correct. He states that "the inferomarginal plates are convex, not carinated". As a matter of fact they are strongly carinated, especially on the lateral face. The deep, narrow, superomarginal and inferomarginal fascioles are lined with very fine spinelets. In Verrill's system, *Leptychaster propinquus* would fall in *Glyphaster*, yet the inferomarginals are as short and oblique as in *Leptychaster pacificus* and the superomarginals are small. Since the marginals are short, the disparity between the number of inferomarginals and adambulacrals is not so great as is emphasized by Verrill for the type *anomalus*. In an adult specimen of *anomalus* there are 16 superomarginals to 29 adambulacrals; in *propinquus* there are 22 superomarginals to 29 adambulacrals; in *pacificus* (*Leptychaster* in Verrill's system) there are 25 superomarginals to 29 adambulacrals.

The curious difference in the male and female gonads, common to the 4 species, is further evidence that they are very closely related. The diversity in body form is no greater than that found in *Odontaster penicillatus*.

On the other hand, the 4 species differ from the southern forms in the distribution of the gonads and in having the less compressed adambulacrals with a rounded instead of sharply angular furrow margin. The inner end of the marginal series of mouth spines lacks the conspicuous decurrent angle found in *Leptychaster accrescens* and *flexuosus*, and less prominently in *magnificus* and *kerguelensis*. After observing the amplitude of

variation in *Odontaster*, I am strongly inclined to follow a middle course and to leave these four species in *Leptychaster*, to which I would add *Trophodiscus*. In order to emphasize what seem to be valid sections I would institute subgenera based upon anatomical characters, the value of which must be determined by experience.

Genus *Leptychaster* Smith

Subgenus *Leptychaster*. Type *L. kerguelensis*. Form stellate; adambulacrals short, with very angular furrow margin; gonads of both sexes in several to many tufts extending along dorsal wall of ray; marginal mouth spines forming a decurrent angle near inner end of plates.

- a*¹. Papulae confined to rather narrow marginal area, where plates have short lobes; elsewhere roundish.
- b*¹. Series of gonads near margin of abactinal area; paedophoric. *L. kerguelensis* Smith.
- b*². Series of gonads well spaced from margin: rays very long; probably not paedophoric. *L. flexuosus* Koehler.
- a*². Papulae distributed all over abactinal surface; all abactinal plates, except in young of *accrescens*, strongly lobed; species probably not paedophoric. *L. magnificus* (Koehler).
L. accrescens Koehler.

Subgenus *Parastropecten* Ludwig. Type *P. inermis* Ludwig (*Glyphaster* Verrill, type *Leptychaster anomalus* Fisher). Form stellate to arcuate stellato-pentagonal; adambulacral plates with rounded furrow margin bearing a comb of 3–6 spines; gonads of male in a series, those of female in a strictly interradianal tuft; abactinal plates lobed except for rather narrow radial area free from papulae; marginal mouth spines *not* forming an evident decurrent angle near inner end of plate; probably not paedophoric.

L. inermis Ludwig.¹

L. anomalus Fisher.

L. propinquus Fisher.

L. pacificus Fisher.

L. arcticus (Sars).

Subgenus *Trophodiscus* Fisher. Type *T. almus* Fisher (1917*a*, p. 367, pls. 28–30). Stellate-pentagonal; marginal plates conspicuous, granular; adambulacral armature pectinate; first adambulacral plate compressed; both male and female gonads serially arranged; abactinal plates of papular area with short lobes; papulae absent from centre of disk and narrow midradial band; marginal mouth spines not forming a decurrent angle.

L. almus Fisher.

In the diagnosis of *Trophodiscus* (*loc. cit.*) is the following: "Near to *Leptychaster* Smith, but differing in having both ovaries and testes serially arranged along each side of the proximal half of ray." This error is due to the circumstance that comparison was made with *L. anomalus*, *L. pacificus* and *L. arcticus*, in which the ovaries are interradianal

¹ The type is immature. The species greatly resembles *L. anomalus*. If it happens that the gonads are different from those of *anomalus*, then *Glyphaster* will be available for *anomalus*, *propinquus* and *arcticus*.

and testes in series (subgenus *Parastropecten*, above). In *Trophodiscus* the gonads are as in *Leptychaster*, sensu stricto, and, moreover, the species is *paedophoric*.

It must be freely admitted that there is a wide difference in appearance between *L. kerguelenensis* and *Trophodiscus almus*, which has broad marginals superficially covered with granuliform spinelets. These mask the deep fascicles between the transverse elevated ridges of the plates. One can scarcely believe in the existence of these deep grooves until the plates are cleaned. The first adambulacral plate is of a different form from the others, being compressed, as in *Parastropecten* and *Leptychaster* s.s. In the latter all the plates are normally so short that the slight disparity in the first plate is not so apparent as in *Parastropecten*.

REMARKS ON *PRIAMASTER*. A detailed comparison of "*Priamaster*" *magnificus* and *Leptychaster accrescens* reveals so many points in common that one is forced to conclude that they are closely related species. If *accrescens* is a *Leptychaster*, then *magnificus* falls in the same genus.

Priamaster, of which *magnificus* is the only known species, is eliminated, as is also *Priamasterinae* Fisher,¹ a subfamily of the Radiasteridae for *Priamaster* and *Gephyreaster*. This subfamily was based upon a misconception of *Priamaster*, especially as regards the structure of the tube feet. The distribution of the gonads was not given in the original description. The podia of *Gephyreaster* have well-developed flattish sucking disks, broader than the column of the podium. In *Priamaster*, as in other species of *Leptychaster*, the terminal knob is of a low acorn shape or hemispherical form without a sucking disk, and much narrower than the column of the podium.

In the foregoing synopsis of *Leptychaster* I have indicated two divisions of the subgenus *Leptychaster*. A subgenus *Priamaster* might be justified for the second on the basis of the differences mentioned. However, in young specimens of *accrescens* the distribution of the papulae is interrupted on the ray by a longitudinal band midway between radial line and margin. Between these two bands there is a radial area of papulae. In general facies and in possessing short, angulated adambulacrals the southern species form a fairly homogeneous group. But it is improbable that the *accrescens-magnificus* group is *paedophoric*.

REMARKS ON *MIMASTRELLA*.² Sladen³ has described and figured *Mimaster cognatus*, while Ludwig⁴ added a description and figures of the characteristic spinelets which he compared with those of *Luidia*. These 4-pronged spinelets are equally like those of *Lophaster*, as Koehler⁵ pointed out, but with a vast difference in size.

Mimastrella cognata bears a very close superficial resemblance to *Leptychaster*⁶ in respect to the small paxilliform superomarginals, adambulacral armature, tube feet,

¹ *Ann. Mag. Nat. Hist.*, ser. 8, xx, 1917, p. 172. Also 1919, p. 216.

² Fisher, "Notes on the Systematic Position of Certain Genera and Higher Groups of Starfishes", *Proc. Biol. Soc. Washington*, xxix, 1916, p. 5. Type *Mimaster cognatus* Sladen.

³ Sladen, 1889, p. 336, pl. 47, figs. 3, 4; pl. 62, figs. 4, 5.

⁴ Ludwig, 1903, p. 6, pl. 2, figs. 11-17.

⁵ Koehler, 1920, p. 257.

⁶ Fisher, 1911, pp. 53, 175.

carinated, paxilliform actinal plates, serial gonads. The lateral abactinal plates are 4-lobed and regularly imbricated. The extreme lateral abactinal plates of *L. magnificus* are also 4-lobed and imbricated, while the others are 5- or 6-lobed. Superambulacral plates are present. In *Mimastrella cognata* there is an odd interradian series of actinal intermediate plates extending from mouth plates a third of the distance to margin. If of no great importance, this series is significant since it is found in most species of *Leptychaster*.

In diagnosing *Mimastrella* (*loc. cit.* 1916) I contrasted it with *Radiaster* (olim *Mimaster*), and stated that the tube feet have small sucking disks. They are not functional sucking disks, but are mammiform, and narrower than the podium, as in *Leptychaster*, and allied genera.

No *Leptychaster* which I have examined has the 3- or 4-pronged terminally flaring spinelets¹ of *Mimastrella*. Whether this character, and the somewhat reduced, more paxilliform, inferomarginals are of superspecific value, only other species of *Mimastrella* will demonstrate.

M. cognata may be described as a *Leptychaster* with narrow inferomarginals, and highly characteristic (mostly) 4-pronged spinelets. Whether such an aberrant species should be given generic rank or relegated to a subgenus is a matter of opinion. Were it not for the spinelets I would hardly hesitate to include it in *Leptychaster*. As matters stand it is probably best to maintain a genus *Mimastrella*.

Leptychaster kerguelensis Smith

Leptychaster kerguelensis Smith, *Ann. Mag. Nat. Hist.*, ser. 4, xvii, 1876, p. 110.

Leptotychoaster kerguelensis Smith, *Philos. Trans. Roy. Soc.*, Zool. Kerguelen Island, CLXVIII, p. 278, pl. 17, fig. 2.—Sladen, 1889, p. 184, pl. 31, figs. 1, 2; pl. 32, figs. 1, 2.

Leptotychoaster kerguelensis, Koehler, 1917, p. 52, pl. 6, figs. 1, 2, 7, 12.

St. 1562. Vicinity of Marion Island, 46° 53' S, 37° 55' E, 97–104 m., 3 specimens.

St. 1563. Vicinity of Marion Island, 46° 48.4' S, 37° 49.2' E, 101–106 m., 1 specimen.

The specimen from St. 1563 measures R 53 mm., r 13 mm., br 15–16 mm.; the largest of the three from St. 1562 has R 23 mm., r 7 mm.

Both Sladen (1889) and Koehler (1917) have described and figured this species. Their largest specimens measured R 66 and 65 mm., r 13 mm. The specimen from St. 1563 agrees well with Koehler's figures (1917, pl. 6, figs. 1, 2). His fig. 1 shows the considerable disparity in size between the small paxillae of centre of disk and radial region of ray and the obviously large ones of the lateral part of the abactinal area. Sladen's figure does not bring this out.

Koehler has also discussed *Leptychaster antarcticus* which Bell (1908, p. 9) recorded as the young of *kerguelensis*, although the type has a different oral armature and more numerous adambulacral spines, differently disposed. Bell's large specimens of

¹ Koehler (1920) figures spinelets of *accrescens*, pl. 74, fig. 1; *magnificus*, fig. 2; *flexuosus*, pl. 75, fig. 3; *arcticus*, fig. 4; *kerguelensis*, fig. 6. I have found that spinelets of *anomalous*, *propinquus* and *pacificus* are of the general type of *arcticus*.

"*kerguelenensis*" from Victoria Land are either *L. accrescens* or *magnificus*, or both. Whether his records from the Cape of Good Hope really refer to this species can only be determined by an examination of his specimens. Mortensen (1933) omits the species from his revised list of sea stars of South African seas.

TYPE LOCALITY. Kerguelen Island.

DISTRIBUTION. Kerguelen Island and Marion Island regions, shore to 384 m.

Leptychaster kerguelenensis mendosus Koehler

Leptotychoaster mendosus Koehler, 1923, p. 98, pl. 12, figs. 3-5.

St. WS 86, Falkland Islands, 53° 53' S, 60° 34' 30" W, 151-147 m., sand, shells, stones, 1 specimen.

Koehler's only specimen measured R 40 mm., r 11 mm. The details of plates and spines are closely similar to those of *kerguelenensis*. In *mendosus* the ray has a slightly different contour, being broader and tapering from a less arcuate interbrachium. There is less disparity in size between the mesial and lateral abactinal paxillae.

It seems obvious that this form is very close to *kerguelenensis*, at best a race of that species, for which reason I have employed a trinomial designation.

TYPE LOCALITY. East of Tierra del Fuego, 54° 43' S, 64° 8' W, 86 m.

Leptychaster flexuosus Koehler

Leptotychoaster flexuosus Koehler, 1920, p. 252, pl. 51, figs. 1-4; pl. 75, fig. 3.

St. 1660. Ross Sea, 74° 46.4' S, 178° 23.4' E, 351 m., 2 specimens.

This remarkable species has been fully described and figured by Koehler, whose only specimen measured R 130-135 mm., r 26 mm. The larger Discovery specimen measures R 340-345 mm., r 36 mm., br 36 mm., breadth of ray half way to tip 13 mm. At this point the inferomarginal plates are 2 mm. broad by 1 mm. long; the superomarginal paxillae are 0.5-0.75 mm. broad. There are 358 inferomarginals in one series from interbrachial angle to tip of the ray.

There is a conspicuous band along the middle of the abactinal area of ray free from papulae. The abactinal plates are roundish, except a narrow band adjacent to superomarginals. Here 4 or 5 plates of each oblique transverse row have short lobes.

The functional gonads (male) are in tufts hanging from the genital stolon which is well spaced from the superomarginals. They extend along ray from interbrachial angle a distance equal to the minor radius. The genital stolon with very small undeveloped gonads can be traced about the same distance beyond the functional gonads. But, with such long rays, the point is only at about the end of basal fifth of ray.

In this species, the angular series of marginal mouth spinelets which extends downward to the peristome is well developed and rather more accentuated than in *accrescens* and *magnificus*. It is also more sharply angular than in the small specimens of *kerguelenensis* available for study.

On the inner side of the base of the tube feet are numerous papilliform outgrowths which, when podia are contracted, touch the radial nerve and those of opposite podia.

Although this species is sharply differentiated from all others of the subgenus *Leptychaster*, I think it is closer to *kerguelenensis* than to *accrescens*.

It would be a matter of great interest to know the behaviour of this species and the part played by the extraordinary rays.

TYPE LOCALITY. Lat. $66^{\circ} 55' S$, long. $145^{\circ} 21' E$, 318 fathoms (just within Antarctic Circle, north-east of Ross Sea proper).

DISTRIBUTION. Known only from type locality and St. 1660, Ross Sea.

Leptychaster accrescens Koehler

Leptotychoaster kerguelensis Bell (nec Smith), 1908, p. 9.

Leptotychoaster accrescens Koehler, 1920, p. 246, pl. 52, fig. 5; pl. 53, figs. 1-3; pl. 54, figs. 2-9; pl. 55, fig. 1; pl. 74, fig. 1.—1923, p. 98, pl. 13, fig. 3.

St. 42. Off mouth of Cumberland Bay, South Georgia, 120-204 m., 3 specimens, largest R 110 mm.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122-135 m., green mud, stones, 1 specimen.

St. 148. Off Cape Saunders, South Georgia, 132-146 m., grey mud and stones, 2 specimens, 1 very large, R 235 mm.

St. 474. One mile west of Shag Rocks, South Georgia, 199 m., 1 very young specimen.

St. 1660, Ross Sea, $74^{\circ} 46.4' S$, $178^{\circ} 23.4' E$, 351 m., 3 specimens.

St. 2467. Near Bouvet Island, $54^{\circ} 24.1' S$, $3^{\circ} 15.2' E$, 124-119 m., 3 specimens.

St. 2563. Near Bouvet Island, $54^{\circ} 23.8' S$, $3^{\circ} 28.4' E$, 97 m., 1 specimen.

Koehler has fully described and figured this species and listed the external features which differ from those of *Leptychaster kerguelensis*. It is in reality far removed from that species. Examples of *accrescens* of the size of adult *kerquelenensis* (i.e. R 45 mm.) are quite immature, the gonads being scarcely discernible. Indeed, in a specimen as large as R 110 mm. the gonads which extend for two-thirds the length of ray are very small (1 April 1926); while in the largest example from the same region (9 January 1927) the large ovaries contain fully formed eggs (R 235 mm.).

Bell's large specimens, presumably from Victoria Land, are certainly not *L. kerguelensis*. They are either this species or *L. magnificus*.

In the largest specimen, St. 148, R=235-240 mm., r=80 mm., R=3r; br=90 mm. This is an imposing sea star. The 4-ranked tube feet are bulky, even in the contracted condition being 15-20 mm. long, 7-8 mm. thick, and terminated by a convex or hemispherical nipple, 2 mm. in diameter. If the power of extension is equal to that of young specimens the tube feet can easily reach 45 mm. One tube foot is bifurcate with two terminal knobs.

The adambulacral plates are distorted by the external row of tube feet so that two or sometimes three angular furrow margins intervene between two external podia (and correspond to the alternate, inner podium). Directly across ray from such a double furrow margin is an interval; that is, an external podium. This distortion is indicated in a specimen as small as R 62 mm., and is well marked in the specimen with R 110 mm. It is also characteristic of *L. magnificus*.

The adambulacral armature of *accrescens* and *magnificus* is also similar. Both have the

short furrow spinelet on the angular margin of plate, followed by 5-7 longer subambulacral spines in 3 longitudinal series of 2 each; or 2 series with an odd spine behind furrow spine, or on outer margin of plate. The plates are characteristically shorter than broad and are distorted in adult specimens as indicated above.

The rays of *magnificus* are more arched, the paxillae slightly larger, and the marginal plates less numerous. In *accrescens* with R 110 mm. there are 90 inferomarginals, and in *magnificus* with R 117 mm. there are 67. This difference is evident from Koehler's figures. At interbranchial angle the width of the combined marginal plates is about the same in the two species, but in *magnificus* the superomarginals are a little larger. The slight disparity in size between the upper and lower marginal plates of Koehler's figure is not constant; in our specimen of *magnificus* there is a marked disparity. Both species have an equally high narrow keel to the marginal plates, separating very deep marginal fasciolar furrows. I am at a loss to understand Koehler's statement that they are shallower in *magnificus*. He uses this as a differential character of *Priamaster*. The gonads are distributed precisely alike in the two species. In the two comparable specimens there is so little difference in the extent of the actinal intermediate areas that it is rather futile to contrast them. In our specimens there are slightly more spinelets on the actinal paxillae of *accrescens*.

The abactinal plates are stellate, with 5 or 6 rather slender lobes, on the radial as well as on lateral parts of the abactinal area. In mature specimens there is no median radial area free from papulae. In young examples, however, this continuity is interrupted by two adradial bands, free from papulae. There are thus on the rays two marginal and a radial area of papulae.

The colour in life is pale yellow with interradial bars of chocolate brown extending nearly to centre of disk and a cross-bar of brown near end of ray (R 110 mm.). In the very large specimen only the latter markings are present; and in four small examples only the interradial bars are present. The examples from Ross Sea lack the brown markings. The largest specimen from St. 2467 was bright orange, tube feet dark orange.

After the completion of this report, Dr N. A. Mackintosh sent photographs of a large specimen and records of others. Three specimens from St. 2467 measure respectively R 260, 260, 230 mm., r 85, 80, 80 mm., breadth of ray at base in all three 90 mm. The specimen from St. 2563 measures R 230 mm., r 65 mm., br 80 mm.

TYPE LOCALITY. Not indicated. Probably 65° 42' S, 92° 10' E, 60 fathoms.

DISTRIBUTION. The species is evidently circumpolar. It was taken by the Australasian Antarctic Expedition between 64° 32' and 66° 50' S, and 92° 10' and 142° 6' E, 60-354 fathoms. Probably at least some of Bell's specimens from Victoria Land are referable to *accrescens*. Koehler has already reported it from South Georgia (1923, p. 98).

Leptychaster magnificus (Koehler)

Asterias longstaffi Bell? 1908, p. 7. In any event the name is a *nomen nudum*, since the printed matter which follows it is misleading, and in no wise describes the specimen. I have seen the type.

Priamaster magnificus Koehler, 1912, p. 92, pl. 8, figs. 1, 3, 8.—1920, p. 255.

St. 599. Off Loubet Land, east of Adelaide Island, 67° 08' S, 69° 06½' W, 203 m., 1 specimen.

The specimen measures R 117 mm., r 25 mm.; R=3.3 r; breadth of ray at interradial line, 41 mm. It is therefore smaller than Koehler's type which measured R 192 mm., r 63 mm., br 70 mm.

Koehler (1912) has given a detailed description and excellent figure. Later (1920) he recognized the close similarity between his *Priamaster* and *Leptychaster* but could not come to the point of abandoning *Priamaster*. Character by character *Priamaster* is a *Leptychaster*. I have ascertained that the gonads have a distribution very similar to those of *L. kerguelensis*, a specimen of which I have examined. This is one of the examples mentioned by Sladen (1889, p. 186) from Marion Island, R 38 mm., r 11 mm. In typical *Leptychaster*, both male and female, the gonads form a series of tufts or lobes, slightly spaced, depending from the genital stolon and extending far along the ray. In *L. kerguelensis* the ovaries form a series close to the inner edge of superomarginal plates for half the length of the ray. In the giant specimen of *L. accrescens* the ovaries are far removed from the margin (a little nearer radial line than margin) and the long, divided lobes form rather voluminous, spaced, tufts extending for two-thirds the length of ray. A male specimen (St. 42) having R 110 mm. has a similar distribution of the gonads. In *L. magnificus* the gonads are distributed precisely as in *accrescens*.

The two large species differ from the small *kerguelensis* in having the genital stolon, and its dependent gonads, far removed from the margin of abactinal area. If *Priamaster* is a valid genus, then *accrescens* is also a *Priamaster*.

The large, 4-ranked tube feet are characteristic of both *magnificus* and *accrescens*. In young *accrescens* (R 64 mm.) the crowded, imperfectly 4-ranked condition is characteristic of only the proximal half of furrow. In a specimen with R 110 mm. the crowding occupies about two-thirds length of furrow—rather more than in the slightly larger specimen of *magnificus*. Koehler's type of *magnificus* (R 193 mm.) with a more extensive development of the 4-ranked condition compares with the large *accrescens*, from St. 148, in which R is 235 mm. and the tube feet are 4-ranked to within 25–50 mm. of tip of ray.

The characters which Koehler invokes in support of a separate genus *Priamaster* are: (1) different form of body; (2) reduced actinal interradial areas; (3) nearly equal size of upper and lower marginal plates; (4) superomarginals not visible when one views the specimen from above; (5) the inferomarginal plates at beginning of series do not have a salient keel as in true *Leptychaster*; (6) the madreporic plate is visible; (7) the ambulacral furrow is much wider than in *L. accrescens*.

In rebuttal it may be stated, seriatim: (1) not of generic significance; (2) not more reduced than in *L. kerguelensis*; (3) a varietal character since our specimen has infero-

marginals nearly twice as broad as superomarginals; (4) varietal character; in our specimen visible except in interradiar arc; (5) there is a high keel and this is indicated in Koehler's fig. 1 in the two interradii on right; (6) covered as much as in an equal-sized specimen of *L. accrescens*, in which centre of plate is visible; (7) extremely variable; specimen of *L. accrescens* (R 110 mm.) has wider furrows than *L. magnificus* (R 117 mm.); see second paragraph above.

TYPE LOCALITY. Petermann Island, south of Palmer Archipelago, 40-70 m., mud and pebbles. Co-type from Jenny Island, southern end of Adelaide Island, 5 m., pebbles.

DISTRIBUTION. Vicinity of Adelaide Island and Petermann Island (McMurdo Strait, Victoria Land, if "*Asterias longstaffi*" is this species).

Genus *Bathybiaster* Danielssen & Koren

Bathybiaster Danielssen & Koren, *Nyt Mag. for Naturvidensk.*, xxvii, part 4, 1883, p. 285. Type *Astropecten pallidus* D. & K. 1877 = *Archaster vexillifer* Wyville Thomson, 1873.

Ilyaster Danielssen & Koren, *Nyt Mag. for Naturvidensk.*, xxviii, part 1, p. 4. Type *Ilyaster mirabilis* D. & K.

Phoxaster Sladen, *Narr. Chall. Exp.*, 1, 1885, p. 611 (no species); 1889, p. 234. Type *Phoxaster pumilis* Sladen.

The north Atlantic *Bathybiaster vexillifer* (Wyville Thompson, 1873), *B. pallidus* (Danielssen & Koren, 1877), and *B. robustus* (Verrill, 1884), are forms of the same species, which takes the oldest name, *vexillifer*.

The circumpolar Antarctic *B. loripes obesus* and its warmer water race *B. loripes* are very similar to *B. vexillifer* and are subject to a corresponding range of variation. If the southern forms are compared side by side with equal-sized *B. vexillifer* and *vexillifer robustus*, it is at once seen that the southern forms have shorter, hence more numerous, marginal plates. Three specimens with R 107 mm. are as follows: *B. vexillifer robustus* 63 marginals. [In typical *vexillifer* (or *pallidus*, for which see Danielssen & Koren, 1884, pl. 14, fig. 1), the marginals are 63 in a specimen with R 107 mm.] *B. loripes*, 70 marginals; *B. loripes obesus*, 127 marginals. Another specimen of *obesus* from the same station (167) with R 140 mm. likewise has 127 marginal plates.

Probably it is obvious enough that *Bathybiaster* and *Psilaster* are very closely related and actually difficult to separate on the basis of the adambulacral armature and the fleshy covering of the actinal intermediate spinelets. The armature of the marginal plates is of no value. In *Bathybiaster*, however, the abactinal paxillae of the papular area (which excludes a narrow strip along radius) have a 6-lobed or stellate base. The plates imbricate strongly by means of these lobes. The plates of the radial strip are not lobed and are in close contact. In typical *Psilaster* the abactinal plates do not imbricate nor are they in contact even along the non-papulated radial area of ray; nor are they lobed, but are circular, polygonal, or elliptical. In the aberrant *Psilaster charcoti* (least *Bathybiaster*-like of any *Psilaster*) the lateral 5 or 6 plates of a transverse series have about 6 slight lobes, of which that on the outer (marginal side) is the largest and touches the

next external plate. But the plates of central portion of abactinal surface are roundish, and are not in contact. It is only the lateral-most part of the papular areas that have the lobed plates, whereas in *Bathybiaster* all the papular area is provided with stellate, imbricating plates. Furthermore, in *Psilaster charcoti* the non-papulated radial area has very distinctly separated plates as in typical *Psilaster*.

Bathybiaster loripes Sladen

Bathybiaster loripes Sladen, 1889, p. 240, pl. 36, figs. 1, 2; pl. 42, figs. 1, 2.

Goniopecten Fleuriaisi Perrier, 1891, p. 140, pl. 12, figs. 2a, 2b; p. 190.

Bathybiaster spinulatus Koehler, 1917, p. 55, pl. 6, figs. 13, 14, 16, 17. Kerguelen, shallow water.

St. WS 98. Falkland Plateau, 49° 54' 15" S, 60° 35' 30" W, 171–173 m., 3 specimens.

St. WS 216. Falkland Plateau, 47° 37' S, 60° 50' W, 219–133 m., fine sand, 1 specimen.

St. WS 773. Falkland Plateau, 47° 28' S, 60° 51' W, 291 m., 1 specimen.

St. WS 819B. Falkland Plateau, 52° 45' S, 62° 27½' W, 329–342 m., 8 specimens.

A study of the extensive series of specimens of *loripes* and *obesus* indicates that *obesus* is a circumpolar species, of which *loripes* is a northern, warmer water, race. It is unfortunate that the priority of *loripes* necessitates its use for the species in its widest sense. It would be better biology to call the Falkland form *Bathybiaster obesus loripes*.

The type of *loripes* from the western coast of South America, near the entrance to the Strait of Magellan (245 fathoms) is only medium sized as compared with specimens from the Falkland plateau, the largest of which has R 110 mm.

Sladen's figure depicts the spines as standing out from the rays, whereas in the specimens under observation the inferomarginal spines are closely appressed and very inconspicuous. This somewhat vivacious interpretation by the artist is of psychological importance, since it may easily have influenced Koehler to believe that his *B. liouvillei* (i.e. *obesus*) is more trenchantly different from *loripes* than really is the case. Some specimens of *loripes* have inferomarginal spines as short as they are in *obesus* (Palmer Archipelago), but the latter lack the superomarginal spines of *loripes*. These superomarginal spines of *loripes* are sometimes very inconspicuous. As an extreme variation, they may be lacking altogether, as in one example from St. WS 98; whereas two others have small, broad, squamiform spines.

Bathybiaster spinulatus Koehler, from shallow water, Kerguelen Island, was based on only one specimen having R 90 mm., the description and figures of which leave nothing to be desired. The spinulation of the marginal plates is the principal feature in which *spinulatus* is believed to differ from *loripes*, its obviously nearest relative. It is evident that Koehler relied solely upon Sladen's description and figures of *loripes*. In his rather involved summary of differences, Koehler has invoked the shape, number, and position of the marginal spinules, but his conclusions are untenable since specimens of *loripes* may have as many spines as *spinulatus*, and in precisely the same position! For one item, the upper of the 2 or 3 inferomarginal spines is not always at the extreme upper end of the plate, as Koehler believed, but in large specimens tends to drop a slight but inconstant distance below, forming a somewhat irregular longiseries precisely as

indicated by Koehler's photographic figures of *spinulatus*. The supposed difference in the shape of the furrow spines does not exist.

A priori there is nothing surprising in the occurrence of *loripes* at Kerguelen in shallow water, as temperature is probably the important factor for its survival at any sub-Antarctic locality. Although the race has not been recorded from Macquarie Island it probably occurs there in appropriate surroundings, since a common Falkland species, *Anasterias antarctica*, has been taken. The latter species is the more surprising because it carries its eggs and young and lacks the advantage of pelagic larvae. *Bathybiaster* probably has pelagic larvae.

B. loripes more closely resembles *B. vexillifer* than does *obesus*. *Vexillifer* varies considerably in respect to the spinulation of the marginal plates, so that comparison of this character is unsatisfactory. *Vexillifer* appears to have consistently longer, hence fewer, marginal plates, as noted under *Bathybiaster*, above.

Goniopecten fleuriatsi Perrier, from Beagle Canal, south coast of Tierra del Fuego, is clearly *B. loripes*. Bottom temperatures recorded: 198 m., 8.1° C.; 270 m., 7.7° C.

TYPE LOCALITY. Challenger St. 311, off the western coast of South America, near the entrance to the Strait of Magellan, opposite Port Churruca, 245 fathoms, blue mud, bottom temperature 46° F.

DISTRIBUTION. Strait of Magellan and western entrance, 198–490 m. (Sladen, Perrier); plateau of the Falkland Islands, 219–342 m. ('Discovery'); Kerguelen Island, shallow (Koehler).

Bathybiaster loripes obesus Sladen

Bathybiaster loripes var. *obesa* Sladen, 1889, p. 242.

Bathybiaster liouvillei Koehler, 1912, p. 96, pl. 6, figs. 2, 3, 4, 12; pl. 8, figs. 5, 6; 1920, p. 263, pl. 73, fig. 1; 1923, p. 100.

- St. 30. West Cumberland Bay, South Georgia, 251 m., 2 specimens.
- St. 39. East Cumberland Bay, South Georgia, 179–235 m., grey mud, 1 specimen.
- St. 42. Off mouth of Cumberland Bay, South Georgia, 120–204 m., 10 specimens.
- St. 45. 2.7 miles S, 85° E of Jason Light, South Georgia, 238–270 m., grey mud, 17 specimens.
- St. 123. Off mouth of Cumberland Bay, South Georgia, 230–250 m., grey mud, 5 specimens.
- St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud, stones, 1 specimen.
- St. 160. Near Shag Rocks, 177 m., grey mud, stones, 1 specimen.
- St. 167. Off Signy Island, South Orkneys, 244–344 m., green mud, 2 specimens.
- St. 181. Schollaert Channel, Palmer Archipelago, 160–335 m., mud, 6 specimens.
- St. 182. Schollaert Channel, Palmer Archipelago, 278–500 m., 2 specimens.
- St. 187. Neumayr Channel, Palmer Archipelago, 259 m., mud, 1 specimen.
- St. 458. 7 miles S, 50° W of Cape Circumcision, Bouvet Island, 357–377 m., 2 specimens.
- St. WS 27. South Georgia, 53° 55' S, 38° 0' W, 106–109 m., gravel, 1 specimen.
- St. WS 32. Mouth of Drygalski Fjord, South Georgia, 91–225 m., 3 specimens.
- St. MS 68. East Cumberland Bay, South Georgia, 220–247 m., 1 specimen.
- St. 1660. Ross Sea, 74° 46.4' S, 178° 23.4' E, 351 m., 11 specimens.
- St. 1952. Between Penguin Island and Lion's Rump, King George Island, South Shetlands, 367–383 m., 1 specimen.

This form has been fully described and figured by Koehler. It is regrettable that his name, *liouvillei*, is untenable. It is apparent from Sladen's description that his Kerguelen

specimens from 127 fathoms are referable to the Antarctic form, and I have confirmed this by an examination of an example from the type locality, Challenger St. 149H. Although this specimen is small (R 47 mm.) it shows the characteristics of the Antarctic form rather than of *loripes*.

Since both forms are variable in the robustness of ray and the rather confusing matter of marginal spinules, the most constant difference seems to be the greater number of marginal plates in *obesus*. In two specimens, each having R 107 mm., *obesus* has 127 marginal plates while *loripes* has 70. These short marginal plates are well brought out in Koehler's figures. In general, Sladen's observations hold good. He says, p. 243:

"The rays are rather more distinctly cylindrical, the union of the abactinal and lateral areas being less angular and less conspicuous. The abactinal area is habitually much more inflated which gives the variety a conspicuously puffed up appearance. The small isolated spinelets or enlarged squamules on the marginal plates are smaller and less developed; and in young examples may be absent altogether from the inferomarginal plates and represented on the summit of the superomarginal plates by a squamule only very slightly greater than those forming the rest of the covering of the plates."

The specimens from St. 458, Bouvet Island, 357-377 m., are clearly *obesus*, as are those from South Georgia. Large specimens from South Georgia, the Palmer Islands, and South Orkneys have a very small superomarginal spinule at the upper end of the plate and also a second at about the middle; while the inferomarginals carry, proximally 3 or 4 small appressed sharp spines in a vertical series and distally 2 or 3. Two very large specimens, from St. 1660, Ross Sea, have R 204 mm. and 175 mm., r 32 mm., and are comparable to Koehler's largest example from Adélie Land, in which R is 170 mm., r 35 mm. (Koehler, 1920, p. 263). There are usually 3 sharp superomarginal spinules and 3 or 4 inferomarginal, very closely appressed to the plates but obviously larger than the rounded squamules covering the plates. A large specimen from St. WS 27, South Georgia, 106-109 m., gravel, has R 160 mm., r 25 mm., and 3 superomarginal spinules in a vertical series, easily distinguished from the broad, rounded squamules covering the plate by their slightly greater length and sharp points. The proximal inferomarginals have usually 4, and the distal inferomarginals 3, similar enlarged spinules.

For purposes of recognition the following points may be stressed. The rays of *obesus* have more rounded sides, and there is a less evident angle of demarcation between the lateral and abactinal surface of the ray, which (especially in the high Antarctic specimens) is inflated or "puffed up". But the rays are not broader at the base in medium-sized and large specimens. All the marginal spinules are smaller in *obesus*, the uppermost superomarginal spinule being very small, or absent. The abactinal paxillae of *obesus* "run" slightly smaller than in *loripes*, but are not invariably so, for in a specimen from St. 167, South Orkneys, with R 140 mm., they measure very close to the paxillae of *loripes* from St. WS 819. The number of marginal plates is a very tangible character when there are specimens of *loripes* for comparison.

TYPE LOCALITY. Challenger St. 149H. Off Cumberland Bay, Kerguelen Island, 127 fathoms, volcanic mud.

DISTRIBUTION. Antarctic, circumpolar. Kerguelen, 127 fathoms, volcanic mud (Sladen). South Shetlands, 18–420 m., mud; Adélie Land, 151 fathoms; Shag Rock Bank, 160 m., gravel, sand; South Georgia, 250–310 m., clay (Koehler).

South Georgia, 91–270 m.; South Orkneys, 244–344 m.; Palmer Islands, 160–500 m.; Bouvet Island, 357–377 m.; Ross Sea, 351 m. ('Discovery').

Genus *Psilaster* Sladen

Psilaster Sladen, *Narr. Chall. Exp.*, 1, 1885, p. 611. Type *Astropecten andromeda* M. & T.

Ripaster Koehler, 1906, p. 4. Type *R. charcoti* Koehler.

Phidiaster Koehler, 1909, p. 28. Type *Ph. agassizi* Koehler.

REMARKS ON *RIPASTER*. There are enough young specimens to give a hint as to the relationship of the genus *Ripaster* since they are more "generalized" than the adults. The smallest has R 5.5 mm., r 2.5 mm. Up to a size where R is 16–20 mm., and R equal to about 3 r, they resemble a *Leptychaster* with a vertical comb of 3 or 4 appressed inferomarginal spines. The superomarginal spines are just beginning to differentiate from the other spinelets of the plate and would not be significant if we did not know the end result. No *Leptychaster*, of course, has specialized marginal spines. As a consequence such a sea star would probably be allocated to *Psilaster*, rather than to *Persephonaster* especially if the mouth and adambulacral plates were carefully examined.

Koehler compared *Ripaster* with *Dytaster*. It has nothing to do with that rather specialized and easily recognized genus. *Ripaster* in general appearance closely resembles a *Persephonaster* of the broad-rayed type, such as *P. euryactis* of the Philippines. This resemblance concerns especially the form of ray, its attenuation at extremity and the bristling marginal armature. Like *Persephonaster*, *Ripaster* has the gonads confined to the interradial region and lacks, in the actinal interradial area, an unpaired series of plates extending from the outer end of the mouth-plates nearly or quite to the inferomarginals. Such an unpaired series, more or less well developed, is present in *Leptychaster*, *Blakiaster* and *Astromesites*.

The adambulacral and mouth-plates of *Ripaster* are like those of *Psilaster* rather than *Persephonaster*. The first adambulacral is strongly compressed as in *Psilaster* and *Bathybiaster*, with 2 closely appressed transverse rows of spines, 2 or 3 of which may be allocated to the narrow, angular, furrow margin. Similarly, each mouth-plate carries 2 closely appressed rows of spines extending from outer to inner end of each plate, as in *Psilaster* and *Bathybiaster*. In *Persephonaster* the first adambulacral is nearly or quite like the others, with a furrow comb of 5 or more spines. In *Ripaster*, *Psilaster* and *Bathybiaster* the second adambulacral is also compressed, and even the third shows some distortion in *Bathybiaster* and *Psilaster*. The mouth-plates of *Persephonaster* have a more extensive actinal surface, with numerous intermediate suboral spines. There is a definite marginal comb bordering on the abulacral furrow (not differentiated in *Ripaster*, *Psilaster*, *Bathybiaster*). In *Persephonaster* there is a very characteristic angular group or tuft of small spines at the inner end of each mouth-plate, above the tooth and the obvious marginal spines. These spines¹ are adjacent to the first tube foot, and the upper spinelets

¹ Fisher, 1919, pl. 38, fig. 1.

of the group may be in contact with the peristomial membrane. There is no sign of these in *Ripaster*, *Psilaster*, or *Bathybiaster*.

Koehler makes some point of the structure of the marginal plates. I can find no difference between *Ripaster* and *Psilaster*, except that in *Ripaster* the vertical fasciolar grooves of the marginal plates are a trifle shallower. These are the grooves, lined with ciliary spinelets, which intervene (on the dorsoventral suture line) between the ridge-like tabula of the marginal plates. Each ridge passes unbroken from supero- to infero-marginal plate, and is homologous to the tabulum of the abactinal paxillae.

Whether the more numerous superomarginal spines of *Ripaster* constitute a feature of generic value must remain a matter of opinion. In *Persephonaster* (as in *Astropecten*) superomarginal spines may be absent (*Persephonaster ciugulatus* Fisher) or there may be a vertical comb of them (*P. luzonicus* Fisher). The adults of all described species of *Psilaster* have at least one superomarginal spine.

My feeling is that *charcoti* is a rather aberrant Antarctic outpost of the cosmopolitan *Psilaster*.

Psilaster charcoti (Koehler)

Ripaster charcoti Koehler, 1906, p. 4, pl. 3, figs. 20, 21, 31, 32; 1908, p. 540; 1912, p. 101, pl. 8, fig. 2; 1920, p. 258, pl. 51, fig. 5; pl. 52, fig. 1; pl. 72, fig. 1.

Ripaster longispinus Koehler, 1920, pl. 51, figs. 5-8; pl. 52, figs. 2-4; pl. 72, fig. 2; 1928, p. 95, pl. 12, figs. 6-8.

St. 27. West Cumberland Bay, South Georgia, 110 m., 2 specimens.

St. 30. West Cumberland Bay, South Georgia, 251 m., 2 specimens.

St. 39. East Cumberland Bay, South Georgia, 179-235 m., grey mud, 5 specimens.

St. 45. 2.7 miles S, 85° E of Jason Light, South Georgia, 238-270 m., grey mud, 4 specimens.

St. 123. Off mouth of Cumberland Bay, South Georgia, 230-250 m., grey mud, 2 specimens.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122-136 m., green mud, stones, 2 specimens.

St. 148. Off Cape Saunders, South Georgia, 132-148 m., grey mud, stones, 2 specimens.

St. 170. Off Cape Bowles, Clarence Island, 61° 25' 30" S, 53° 46' W, 242 m., rock, 1 specimen.

St. 181. Schollaert Channel, Palmer Archipelago, 160-335 m., mud, 4 specimens.

St. 182. Neumayr Channel, Palmer Archipelago, 259 m., mud, 1 specimen.

St. 187. Neumayr Channel, Palmer Archipelago, 259 m., 2 specimens.

St. 366. Four cables south of Cook Island, South Sandwich Islands, 77-152 m., 1 specimen.

St. 371. One mile east of Montagu Island, South Sandwich Islands, 99-161 m., 4 specimens.

St. 458. Seven miles S, 50° W of Cape Circumcision, Bouvet Island, 357-377 m., 1 very young specimen.

St. WS 27. South Georgia, 53° 55' S, 38° 01' W, 106-109 m., gravel, 2 specimens.

St. WS 32. Mouth of Drygalski Fjord, South Georgia, 91-225 m., 3 specimens.

St. WS 865. 50° 03' S, 64° 14' W, 126 m., 3 specimens.

St. MS 68. East Cumberland Bay, South Georgia, 220-247 m., 3 specimens.

St. 356. Terra Nova (loaned by British Museum, register 1914.8.12.17-18; labelled "*Asterias longstaffi*" by Prof. F. J. Bell; an example of forma *longispinus*).

St. 1660. Ross Sea, 74° 46.4' S, 178° 23.4' E, 351 m., 10 specimens (forma *longispinus*).

St. 1952. Between Penguin Island and Lion's Rump, King George Island, South Shetlands, 367-383 m., 1 specimen, R 163 mm., r 42 mm. (forma *longispinus*).

St. 1957. Off south side of Clarence Island, South Shetlands, 2 specimens (forma *longispinus*).

This species has been minutely described and elaborately figured by Koehler, who separated the extremes of variation under two specific names. The anomalies of distribution apparently raised no question since he recorded the two "species" from the same dredge haul.

It is perfectly apparent from the fine series under observation that we have an Antarctic species which has practically the same geographic distribution as *Bathybiaster loripes obesus*. Specimens with shorter superomarginal spines and referable to forma *charcoti* are found at South Georgia where the long-spined form also occurs. The latter also occurs in the high Antarctic localities, such as the Palmer Archipelago, Ross Sea, and latitude $65^{\circ} 06'$ to $66^{\circ} 55'$ S, longitude 96° to 145° E (type series of *longispinus*). At one of the stations in this area, together with *longispinus*, *charcoti* was dredged.

While the extremes are as Koehler has described them, there are intermediates which are with difficulty assigned to either forma. Perhaps this is another way of saying that both formae are variable. For instance, there is as much latitude of variation between figs. 6 and 8, pl. 12 (Koehler, 1920) representing *longispinus* as there is between the same fig. 6, and fig. 2, pl. 8 (Koehler, 1912) representing *charcoti*. Also, the contrasting figures given by Koehler (1920, pl. 51, fig. 5, *charcoti* and fig. 6, *longispinus*; pl. 52, fig. 1, *charcoti* and fig. 2, *longispinus*) represent the very extremes of difference. In the Discovery collection are examples connecting these two extremes. No sharp line of distinction can be drawn separating two species, or even two formae of the same species.

COLOUR NOTES. St. 1952, large specimen, bright pink above, yellow below. St. 1957, abactinal surface pale delicate pink, inclining to delicate purple towards and at centre.

TYPE LOCALITY. Booth-Wandel Island, south of Palmer Archipelago. Paratypes from Wincke Islands and Briscoe Islands.

DISTRIBUTION. Circumpolar. In the western hemisphere: Briscoe Islands, Wandel Island, Palmer Archipelago, South Shetlands 30–75 m., mud, pebbles, rocks, grey mud (Koehler); 160–335 m. ('Discovery'). Clarence Island 242 m., rock ('Discovery'). South of South Orkneys, 1775 fathoms (Koehler). South Sandwich Islands ('Discovery'). South Georgia, 75–310 m., stones, clay (Koehler); 91–270 m., grey mud, stones ('Discovery').

Eastern hemisphere: Area comprising $92^{\circ} 10'$ to $145^{\circ} 21'$ E and $65^{\circ} 06'$ to $66^{\circ} 55'$ S, 60–325 fathoms (Koehler). Bouvet Island, 357–377 m.; Ross Sea, 351 m. ('Discovery').

Family BENTHOPECTINIDAE Verrill

Genus *Pontaster* Sladen

Pontaster Sladen, *Narr. Challenger Exp.*, 1, 1885, p. 610; 1889, p. 23. Type *Astropecten tenuispinus* Düben & Koren.—Ludwig, 1910, p. 447.

Pontaster planeta Sladen

Pontaster planeta Sladen, 1889, p. 30, pl. 10, figs. 1, 2; pl. 13, figs. 1, 2.—Ludwig, 1910, p. 447.

St. WS 821. South of West Island, Falkland Islands, $52^{\circ} 55\frac{3}{4}'$ S, $60^{\circ} 55'$ W, 351–367 m., 1 specimen.

The type measures R 37 mm., r 6.5 mm., $R=5.5$ r. The present specimen measures R 100 mm., r 20 mm., $R=5$ r. Its large size is therefore remarkable. Comparison of this specimen has been made with one from the type locality and there are no differences which cannot be attributed to the disparity of size.

The central enlarged spinule of paxillae is present all over the abactinal area. Some plates of disk have 3 or 4 of these. Of the smaller secondary spinelets, there may be 20 co-ordinated in a convex group on larger plates of disk while much smaller interpolated secondary plates have only 5 or 6, and no enlarged spinule. The superomarginal plates carry a single, sharp, subconical spine 3 mm. long at base of ray. Proximal inferomarginals with a similar, lateral, spine 4.5 mm. long; and on actinal surface of plate, 3 or 2 successively smaller spines in a transverse series. Distally these accessory marginals are usually 2, then 1. The secondary spinelets are very slender, spaced, and lengthened adjacent to the principal spines.

Similar, slender, spaced, spinelets cover the actinal interradial area, the plates of which form about 4 chevrons with some extra plates adjacent to first inferomarginals. Plates of innermost row extend to fourth inferomarginal. Most of actinal plates with 1 or 2 enlarged central spinules.

Adambulacral plates with a prominent furrow margin as described and figured by Sladen. Six or seven spinelets can be assigned to this angular margin, but the same series is continued along the adoral transverse edge of plate by 4-6 additional, similar spinelets. The actinal surface is occupied by the broadened bases of the subambulacrals, which vary from 2 to 4, are robust, about 3 mm. long, slightly tapered beyond the base, and are bluntly pointed; or, in the case of the second from furrow, subclavate with compressed, subtruncate tip.

The *combined* mouth-plates form a broad subtruncate projection nearly as broad as the length of interradial dimension. On the broad actinostomial margin are 6 stout, tapered, flattened spines (3 to each plate), the central pair about 3 mm. long. On the furrow margin, continuing this series, are 4 much smaller spines. The actinal surface is occupied by about 8 or 9 prominent tapered acute spines.

The papularium of each ray is perfectly flat, for which reason its extent is not easy to determine from the outside. It is strongly bilobed distally. Total length about 12 mm.; breadth 6.5 mm.; length of each lobe 8 mm. Papulae small, well spaced.

The dorsal muscle bands are well developed, about 4 mm. broad, slightly spaced from one another. The inner, truncate end is attached to abactinal wall opposite ninth ambulacral ossicle. From the outer corner of this inner end a *rudimentary* tendon connects with a thin specialized dorsal crest of eighth ambulacral ossicle. This ridge is perceptibly higher than that of seventh or ninth plates. In this respect *Pontaster* is more nearly like *Cheiraster* than *Pectinaster*. In the latter the tendon is better developed.

Pedicellariae are not present.

COLOUR NOTE. Disk and base of arms pale warm pink.

TYPE LOCALITY. Challenger St. 311, off western coast of South America, near the

entrance to the Straits of Magellan, opposite Port Churruca, 245 fathoms, blue mud; bottom temperature 46° F.

DISTRIBUTION. Slopes of Falkland-Cape Horn Plateau, 350–500 m.

Genus *Luidiaster* Studer

Luidiaster Studer, *Sitzungsber. naturforsch. Freunde, Berlin*, 16 Oct. 1883, p. 131. Type *L. hirsutus*

Studer.—Ludwig, 1910, p. 451.—Fisher, 1911, p. 127.—Verrill, 1914, p. 311.

Acantharchaster Verrill, *Proc. U.S. Nat. Mus.*, xvii, 1894, p. 268. Type *Archaster dawsoni* Verrill.

Luidiaster gerlachei (Ludwig)

Cheiraster gerlachei Ludwig, 1903, p. 9, pl. 1, figs. 1–8; pl. 2, figs. 9, 10.

Luidiaster gerlachei Ludwig, 1910, pp. 252, 253.—Fisher, 1911, p. 127.—Koehler, 1920, p. 244, pl. 55, figs. 2–5; pl. 65, fig. 8.

St. 181. Schollaert Channel, Palmer Archipelago, 160–335 m., mud, 5 specimens.

St. 1660. Ross Sea, 74° 46' 4" S, 178° 23' 4" E, 351 m., 18 specimens, R 20 to R 76 mm.

St. 1957. Off south side of Clarence Island, South Shetlands, 785–810 m., 11 specimens.

The largest specimen (St. 181) has R 110 mm., r 18 mm., $R=6.1\ r$; br at interradius 20 mm., at fifth superomarginal, 15 mm. Ludwig's largest specimen had R 78 mm., while Koehler's measured R 54 mm.

Ludwig has described this species in great detail. Koehler has supplied notes on variations as well as very useful photographic figures.

In his second paper, Ludwig (1910, p. 453) contrasts *gerlachei* with the much older *hirsutus* of Studer, of which he had two specimens. According to this synopsis *hirsutus* has a double circlet of smaller spinelets surrounding the central spine of the paxillae, unequal ventrolateral spinelets, and pedicellariae on the ventrolateral plates only. *Gerlachei* has a single circlet of paxillar spinelets, equal ventrolateral spinelets, and pedicellariae on the ventrolateral as well as on other plates.

In the Discovery specimens the first character holds fairly well, but some of the larger plates of disk of biggest specimen have a second circle, or extra spinelets within the single circle. This specimen has *unequal* actinal intermediate (ventrolateral) spines. To be more precise an elongate central spine is surrounded by smaller, unequal secondary spinules. This disparity is exhibited by the smallest specimen, R 20 mm., St. 1660. In the largest specimen there are numerous large pectinate pedicellariae on actinal interradial areas, especially adjacent to adambulacrals, which are continued far along ray between the inferomarginals; but in three other examples (R 33 to R 55 mm.) the pedicellariae are confined to actinal interradian areas (sometimes only one pedicellaria to an area).

Ludwig states in the same synopsis, that both *hirsutus* and *gerlachei* differ from *teres* in having one inferomarginal spine while *teres* has two. The largest specimen (R 110 mm.) has regularly 2 inferomarginal spines, the longer of which near base of ray, measures 8 mm., and the shorter 4 or 5 mm. Two other specimens also have the second spine developed.

The very angular furrow margin of the adambulacral plates carries 8 or 9 spines and 3-5 others along the adoral border; subambulacral spines 2, slender, slightly curved, the longer about 6 mm. at base of ray; on disk they are a little shorter, subcylindrical, blunt.

The dorsal muscle bands meet along the median line. In the specimen examined, the short tendon from the inner end of band passes over the inner face of marginal plates (to which it is attached) and fastens to a specialized crest of the seventh ambulacral ossicle, on one side of ray, and to eighth on the other side.

Ludwig planned a much fuller treatment of the *Notomyota* than the frankly preliminary account of 1910. Unfortunately this work was never realized. No detailed description and no figures of *L. hirsutus* have been published. It will not be surprising if eventually *hirsutus* and *gerlachei* are found to represent two races of a single circumpolar species. The two examples of *hirsutus* studied by Ludwig were taken by the 'Valdivia' at Bouvet Island (03° 30' E, 54° 30' S). The records of *L. gerlachei* are from much further south (64° to 70°).

In 1911 (Fisher, 1911, p. 127) I raised the question whether *Luidiaster dawsoni* is congeneric with *gerlachei*. I have compared specimens and believe that they are. But as shown by Ludwig's key (1910, p. 453) *dawsoni* stands apart by the extraordinary development of its spines, especially those of inferomarginal plates.

TYPE LOCALITY. Southern Bellinghausen Sea, near Ice Barrier, west of Charcot Island.

DISTRIBUTION. Circumpolar, Antarctic, between latitudes 70° and 64° S. Recorded by Ludwig (1903) between 80° 48' and 84° 06' W, 70° and 70° 23' S, 450-560 m. Koehler's specimens were taken by the Australasian Antarctic Expedition between 96° 13' and 145° 31' E, 64° 44' and 66° 55' S, 230-358 fathoms.

Family ODONTASTERIDAE Verrill

Gnathasterinae (pars) Perrier, 1894, pp. 244, 251.—Meissner, 1896, p. 92.

Gnathasteridées Koehler, 1920, p. 179.

Odontasteridae Verrill, 1899, p. 201.—Ludwig, 1903, p. 19.—Fisher, 1905, p. 302; 1911, p. 153, diagnosis—Farquhar, *Trans. New Zealand Inst.*, XLV, 1913, p. 212.

KEY TO THE GENERA OF ODONTASTERIDAE

*a*¹. A recurved, glassy tipped spine on each mouth-plate—two side by side, at each mouth angle.

*b*¹. Marginal plates decreasing regularly in size from base to extremity of rays.

Asterodon Perrier.

*b*². Marginal plates at first increasing in size; rays dilated.

Diplodoutias Fisher.

*a*². At each mouth angle a strongly recurved spine (common to the two plates), the tip of which is normally glassy. On either side of this, a suboral spine sometimes is enlarged and recurved and may have a short glassy tip.

*b*¹. Marginal increasing in size toward extremity of rays.

Eurygonias Farquhar.

*b*². Marginals decreasing in size toward extremity of rays.

- c*¹. Abactinal plates with a distinct tabulum crowned with short to fairly long spinelets; marginal plates small, to well-developed, more or less tabulate, spinulose; actinal area densely spinulose. *Odontaster* Verrill.
- c*². Abactinal plates without a distinct tabulum, but slightly convex. They are crowned with low granules, sometimes involved in a thin integument, which, however, in no way hides them. Marginal plates prominent to small, granulose, not tabulate; actinal areas covered with granules which, in some species, are gradually transformed to spinelets as oral angle is approached. *Acodontaster* Verrill.

From the above synopsis it will be seen that five genera are recognized, whereas Koehler (1920, p. 190) admitted eleven. *Heuresaster* Bell was overlooked, but it is obviously the same as Koehler's *Tridontaster*.

I regret the necessity for departing so widely from the results obtained by Koehler; but it is inevitable since in certain cases he adduced to distinguish his genera characters of only specific, or even less than specific, significance.

It would be useful to separate *Odontaster* from *Gnathaster*, but it cannot be done. For one thing the marginal plates of *Gnathaster* vary widely, if we include such diverse species as *Odontaster validus*, where they are paxilliform, and *O. penicillatus* forma *grayi*, where they are block-like and covered by elongate granules or short spinelets. But *Gnathaster* must include the widely variable *penicillatus*, which bridges the gap to a restricted *Odontaster*.

Unfortunately Koehler made *O. penicillatus* forma *grayi* (i.e. *O. grayi* Bell) the type of *Peridontaster*. *Grayi* intergrades perfectly with *Odontaster penicillatus* (*O. pilulatus* Sladen) which in turn is closely related to *O. meridionalis* (Smith), the type of *Gnathaster*. Such differences as *Odontaster grayi* shows to *O. meridionalis* are therefore not generic. In another direction, *O. grayi* (apart from its pentagonal shape) obviously resembles *O. hispidus*, the type of *Odontaster*! *Odontaster*, *Gnathaster* and *Peridontaster* cannot be separated on the basis of characters now known.

I believe that the small type of *Epidontaster* is the young of *Odontaster meridionalis* having accessory teeth—not an uncommon variation in that species. Only one specimen is cited.

The character of the plates and their armature is the same in *Acodontaster*, *Pseudontaster*, *Metadontaster*, and *Tridontaster* (*Heuresaster* Bell). *Pseudontaster* simply has somewhat smaller marginal plates than has *Acodontaster*. *Pseudontaster moderatus* Koehler and *Ps. stellatus* Koehler, in my opinion, are variants of the circumpolar *Acodontaster elongatus* (Sladen), type of *Acodontaster*. For some curious reason Koehler never recognized *elongatus* (see *Odontaster cremeus* Ludwig, 1903; Koehler, 1912; *Acodontaster cremeus* Koehler, 1920).

In view of the obviously close relationship of *Tridontaster laseroni* to *Acodontaster conspicuus* and the occasional presence of accessory teeth in the latter, I cannot take seriously the use of accessory teeth alone as the criterion of a new genus.

Metadontaster contains a single species *M. waitei*, which is so close to *Acodontaster conspicuus* that I am uncertain whether to call it a species or a form of *conspicuus*.

There follows a list of the Odontasteridae of the southern hemisphere as given in

Koehler's revision of 1920 with the addition of two new species added in 1923. With each is the interpretation given in the present paper:

Koehler	Fisher
<i>Acodontaster elongatus</i> (Sladen) name only	<i>A. elongatus</i>
<i>A. elongatus</i> var <i>abbreviatus</i>	<i>A. conspicuus</i>
<i>A. cremeus</i> (Ludwig)	<i>A. elongatus</i>
<i>A. capitatus</i> (Koehler)	<i>A. elongatus</i> forma <i>capitatus</i>
<i>A. granuliferus</i> (Koehler)	<i>A. elongatus granuliferus</i> forma <i>granuliferus</i>
<i>Pseudontaster marginatus</i> Koehler	<i>A. marginatus</i>
<i>Ps. stellatus</i> Koehler	<i>A. elongatus</i>
<i>Ps. conspicuus</i> Koehler	<i>A. conspicuus</i>
<i>Ps. moderatus</i> Koehler	<i>A. elongatus</i>
<i>Tridontaster laseroni</i> Koehler	<i>A. hodgei</i> (Bell)
<i>Metadontaster waitei</i> Koehler	<i>A. waitei</i>
<i>Gnathaster meridionalis</i> (Smith) name only	<i>Odontaster meridionalis</i>
<i>G. penicillatus</i> (Philippi)	<i>O. penicillatus</i> forma <i>penicillatus</i>
<i>G. validus</i> (Koehler)	<i>O. validus</i>
<i>G. tenuis</i> (Koehler)	<i>O. validus</i> forma <i>tenuis</i>
<i>G. elegans</i> (Koehler)	<i>O. meridionalis</i> (Smith)
<i>Peridontaster grayi</i> (Bell)	<i>O. penicillatus</i> forma <i>grayi</i>
<i>P. pusillus</i> (Koehler)	<i>O. pusillus</i>
<i>Epidontaster pentagonalis</i> Koehler	<i>O. meridionalis</i> juv.
<i>Asterodon singularis</i> (M. & T.)	<i>A. singularis</i> forma <i>singularis</i>

Genus *Odontaster* Verrill

Odontaster Verrill, *Amer. J. Sci.*, xx, 1880, p. 402. Type *O. hispidus* Verrill.

Gnathaster Sladen, 1889, p. 205. Type *G. meridionalis* (Smith).—Perrier, 1894, first reviser.

Gnathodon Verrill, 1899, p. 203 (error).

Epidontaster Koehler, 1920, pp. 191, 195. Type *E. pentagonalis* Koehler = *Odontaster meridionalis* (Smith).

Peridontaster Koehler, 1920, pp. 192, 194. Type *Odontaster grayi* Bell = *O. penicillatus* Philippi, var.

Gymnognathaster Döderlein, 1928, p. 297. Type *G. gaussae* Döderlein (perhaps a young *O. meridionalis*, R 7 mm.).

Odontaster meridionalis (Smith)

Astrogonium meridionale Smith, 1876, p. 109.

Pentagonaster meridionalis Smith, 1879, p. 276, pl. 16, figs. 6, 6a.

Gnathaster meridionalis Sladen, 1889, p. 287, pl. 47, figs. 1, 2; pl. 48, figs. 5, 6; pl. 49, figs. 11, 12.

Odontaster elegans Koehler, 1912, p. 72, pl. 7, figs. 5-11.

Gnathaster elegans Koehler, 1920, p. 227, pl. 41, figs. 7, 8; pl. 71, fig. 4.—1923, p. 85.—Döderlein, 1928, p. 297.

Epidontaster pentagonalis Koehler, 1920, p. 235, pl. 39, figs. 3, 4, 8; pl. 41, figs. 9-11.

St. 160. Near Shag Rocks, 53° 43' 40" S, 40° 57' W, 177 m., grey mud, rocks, 1 specimen.

St. 164. East end of Normanna Strait, South Orkneys, near Cape Hansen, Coronation Island, 24-36 m., 3 specimens.

St. 170. Off Cape Bowles, Clarence Island, 61° 20' 30" S, 53° 46' W, 342 m., rocks, 3 young specimens.

St. 190. Bismarck Strait, Palmer Archipelago, 93-130 m., rock or stones and mud, 3 young specimens.

St. 371. One mile east of Montagu Island, South Sandwich Islands, 99-161 m., 2 large specimens.

- St. 474. One mile west of Shag Rocks, 199 m., 1 specimen.
St. 1562. Marion Island, 46° 53' S, 37° 55' E, 97 m., 4 specimens.
St. 1563. Marion Island, 46° 48.4' S, 47° 49.2' E, 101-106 m., 4 young specimens.
St. 1564. Marion Island, 46° 36.5' S, 38° 02.3' E, 108-113 m., 1 specimen.

This is one of the most handsome sea stars of the Antarctic. The paxillae are well developed with numerous spinelets, of which those occupying the centre of tabulum are characteristically clavate, heavier than the marginal spinelets, and in large specimens quite crowded. The marginal plates can hardly be called paxillae. Rather they are conspicuous squarish blocks with a low broad tabulum crowned by many crowded spinelets, essentially like the abactinal but larger. The largest specimen (R 91 mm., St. 371) has paxillae and marginals with more numerous spinelets than Koehler's fig. 7, pl. 7 (1912). The smallest specimen (St. 190) has R 5 mm. The characteristic thorny tips of the spinelets are described and figured by Koehler.

In the two large specimens (St. 371) each median "tooth" is accompanied on either side by an accessory tooth, actually an enlarged suboral spine (sometimes upright, sometimes bent slightly away from the mouth angle), the tip of which is hyaline. These accessory teeth are developed in a specimen (St. 164) having R 48 mm., but the membrane has not yet retracted from the tip.

For a comparison of this species with *Odontaster validus*, see the table of variations under the latter.

This is an Antarctic species. It is therefore not surprising that the young and medium-sized specimens from Marion Island vary slightly from the Antarctic form. For instance, there is an obvious lack of the slender spinelets which occur on the margin of the paxillae of typical large specimens and which are indicated in Sladen's fig. 1, pl. 47.

Koehler states that his specimens of *elegans* from the region between longitudes 92° and 145° E (64° 32' and 66° 55' S) are in no way different from the types which were collected by the second Charcot Expedition in the Antarctic Archipelago. It is difficult to understand why Koehler overlooked *meridionalis* and compared his *elegans* only with *validus*. There can be no doubt that *meridionalis* and *elegans* are the same species.

Epidontaster pentagonalis Koehler was dredged at St. 8, Australasian Antarctic Expedition, 66° 8' S, 94° 17' E, 120 fathoms, at which *Odontaster meridionalis* was taken. The genus and species is based upon one young specimen having R 17 mm., r 10 mm., characterized by having an accessory "tooth" on either side of the usual median tooth. Otherwise it is a short-rayed *O. meridionalis* very similar to a young specimen (R 8.5 mm.) from St. 170. This small specimen, which has the proportions of Koehler's, shows an incipient accessory tooth on either side of the median. As noted above the two largest specimens, from St. 371, each have the accessory teeth, the extreme hyaline tip of which shows beyond the membranous envelope. In the larger of these two specimens R is 63 mm.; in the other R is 58 mm. It follows therefore that the accessory teeth here, as elsewhere in the *Odontasteridae*, are not of generic significance.

COLOUR NOTE. St. 164, orange yellow, Ridgway scale 170 y.c.

TYPE LOCALITY. Kerguelen Island.

DISTRIBUTION. As far south as Alexander Land ($68^{\circ} 35' S$, $72^{\circ} 40' W$, 297 m.); off Adelaide Island; Petermann Island; Palmer Archipelago; South Orkneys; South Sandwich Islands; South Georgia. East Antarctica from 88° to $145^{\circ} 21' E$ and $64^{\circ} 32'$ to $66^{\circ} 55' S$. Heard Kerguelen and Marion Islands. The greatest depth appears to be 354 fathoms at $66^{\circ} 51' S$, $142^{\circ} 06' E$.

The species is evidently circumpolar, Marion, Kerguelen and South Georgia being its northern outposts.

Odontaster validus Koehler

Odontaster validus Koehler, 1906, p. 6, pl. 3, figs. 22–26.—1908, p. 12.—1911, p. 27.—1912, p. 68, pl. 7, figs. 1–4, 12.

Odontaster tenuis Koehler, 1906, p. 8, pl. 4, figs. 33–38.—1920, p. 232, pl. 40, figs. 1–3, 6; pl. 41, figs. 3, 4; pl. 72, fig. 4.

Cycethra verrucosa Bell, 1908, p. 10, pl. 5, fig. 1*b*.—1917, pl. 1, figs. 1–6 (fide Koehler).

Gnathaster validus Koehler, 1920, p. 228, pl. 34, fig. 10; pl. 40, figs. 4, 5, 7; pl. 41, figs. 2, 5; pl. 72, fig. 3.—1923, p. 84 (Shag Rocks, South Georgia).

St. 145. Stromness Harbour, South Georgia, 26–35 m., 2 specimens.

St. 163. Paul Harbour, Signy Island, South Orkneys, 18–27 m., 18 specimens.

St. 164. East end of Normanna Strait, South Orkneys, near Cape Hansen, Coronation Island, 24–36 m., 97 specimens.

St. 173. Port Foster, Deception Island, South Shetlands, 24 specimens.

St. 368. Douglas Strait, Southern Thule, South Sandwich Islands, 653 m., 2 forma *validus*, 1 forma *tenuis*.

St. 370. Two miles north-east of Bristol Island, South Sandwich Islands, 18–80 m., 8 specimens

St. 456. One mile east of Bouvet Island, 40–45 m., 3 specimens.

St. 1941. Leith Harbour, South Georgia, 55–22 m., 2 specimens.

St. 1959. Scotia Bay, South Orkneys, 5 m., 14 specimens (taken in fish trap).

St. WS 25. Undine Harbour (North), South Georgia, 18–27 m., sand, 6 specimens.

St. WS 62. Wilson Harbour, South Georgia, 15–45 m., 2 specimens.

St. MS 6. East Cumberland Bay, South Georgia, 27 m., 10 specimens.

St. MS 10. Same as MS 6, 27 m., 17 specimens.

St. MS 12. Same as MS 6, 25–53 m., 2 specimens.

St. MS 63. Same as MS 6, 23 m., 8 specimens.

St. MS 71. Same as MS 6, 120–60 m., 1 specimen.

St. MS 74. Same as MS 6, 22–40 m., 3 specimens.

Cumberland Bay, South Georgia, November 1929, 2 specimens.

Koehler has elaborately described and figured this species, which Bell recorded and figured as *Cycethra verrucosa* (1908, p. 10, pl. 5, fig. 1). The British Museum has kindly forwarded one of Bell's specimens from the Discovery Winter Quarters. It is an example of *Odontaster validus* forma *validus* with rather attenuate rays, R 44 mm., r 18.5 mm.

Since there are 97 specimens from St. 164 it seems desirable to analyse the variations found at this station and to include also variants from other localities. These are given in synoptical form and *O. meridionalis* is introduced to indicate its position with reference to the varieties of *validus*. *O. tenuis* intergrades perfectly with the typical form. Of

the latter I have one of the type series, namely, one of the two specimens recorded by Koehler (1906, p. 6) from Booth-Wandel Island.

In the following synopsis to save space I have abbreviated references to Koehler's excellent photographic figures, as follows: VII is pl. 7, Koehler, 1912; XL and XLI are pl. 40 and 41, Koehler, 1920. The numerals following any of these refer to the figures on that particular plate.

The Booth-Wandel specimen has long actinal spines, about the same as in VII, 12, or XL, 5 (left side) but not so long as the extremes included under A^1C^3 below; nor as short as those of A^2 , B^1C^1 ; it lies between these two. On the whole, specimens with actinal spines shorter than the subambulacral (either slightly or decidedly) are more numerous than those having the two sets of spines subequal.

SYNOPSIS OF VARIATIONS OF *ODONTASTER VALIDUS*

- A^1 . Actinal intermediate spines as long as, or nearly as long as, the subambulacral spines. They give the actinal intermediate area a *shaggy* appearance. The outer plates carry only 2 or 3 spines although those near the mouth-plates may have 4-7 (XL, 1, 2, 5).
- B^1 . Marginal, especially the superomarginal plates, small, *spaced*, paxilliform, especially in interradian region, but increasing in size on ray, although still spaced and paxilliform; superomarginal plates of interbrachial region with about 12 (6-15) spines; paxillae small, spaced (VII, 1, 3; XL, 6, 7; XLI, 4, 5).
- C^1 . Abactinal and marginal spines longer; paxillae with longer, slenderer pedicels; with the spinelets they resemble little brushes; rays longer and slenderer (XL, 3). St. 368; forma *tenuis* Koehler.
- C^2 . Rays as in C^1 and abactinal and marginal paxillae still well spaced, but with shorter spinelets; St. 368, 173, intermediate forms.
- C^3 . Rays of moderate length and not especially attenuate distally; abactinal paxillae with lower pedicels (as compared to C^1) and shorter spinelets; marginal plates virtually without pedicels, their spinelets radiating (the plates as a consequence appearing less widely spaced) or compressed into a brushlike group by reason of which the marginal paxillae appear to be more distantly spaced. There are often 1 or 2 small actinal 2- or 3-valved pedicellariae, much shorter than spinelets, near mouth-plates (VII, 1, 3, 4; XL, 7). St. 164, 23 specimens; St. 173, *et al.*
forma *validus*.
- B^2 . Superomarginal plates larger, broader than long, obviously larger than adjacent abactinal paxillae. The spines (15-25) are usually co-ordinated in 3 or 4 transverse series (as in XL, 7, but with more spines, as contrasted with VII, 3). St. 370, St. 456, St. MS 6, *et al.*
forma *validus*.
- A^2 . Actinal intermediate spines distinctly *shorter* than the subambulacral spines, which, as a consequence, form a differentiated *cheval-de-frise* along the border of the ambulacral furrow (VII, 2, 8, 11; 12 is intermediate with A^1); rays usually as in A^1C^3 , but variable; sometimes as long as in forma *tenuis*.
- B^1 . Actinal intermediate spines 1-3 per plate on marginal parts of area and 3-6 near mouth-plates (VII, 2).
- C^1 . As in A^1 , B^1 , C^3 ; paxillae small, well spaced; superomarginals of interbrachium small, paxilliform, with 6-15 spinelets; 1-3 small 2- or 3-valved pedicellariae on actinal plates near mouth-plates (e.g. St. MS 6); 58 specimens St. 140; St. 173; St. 368; St. 370, *et al.*
forma *validus*.

- C^2 . Abactinal paxillae small, as in C^1 , but superomarginal plates larger, bearing, in interbrachium, 20 or more spinelets in a compact group wider than long. St. 370; St. MS 74, *et al.* forma *validus*.
- C^3 . Superomarginal plates paxilliform, with slightly more obvious tabulum than in C^1 , and in interbrachial area with more (18–25) spinelets. The central spinelets are slender and nearly as long as the peripheral. The abactinal paxillae have 10–15 peripheral spinelets and 5–10 similar slender central ones (where typical *validus* has usually 1–4 central and 5–9 peripheral spinelets). Central paxillar spinelets not clavate as in *meridionalis*. This variation intergrades perfectly with typical *validus*. It resembles superficially a variant of *meridionalis* but can be recognized by the fewer actinal spines and slender central paxillar spines. 7 specimens, St. 164. forma *validus*.
- B^2 . Actinal intermediate spines many to a plate, the central usually subclavate and more robust than the peripheral of the group. They form a dense covering for the actinal surface and are usually bent toward the margin. Marginal plates larger than in *validus*, with numerous spines, which form a very compact group, of which the central are more robust and characteristically clavate. Abactinal paxillae large, with numerous central clavate spinelets surrounded by slender peripheral ones. Spines ending in sharp points or awns (VII, 5–11). *O. meridionalis*.

On account of the isolated position of Bouvet Island the three specimens from St. 456, 40–45 m., have been examined with great care since there was naturally some expectation of finding *Odontaster meridionalis*. The specimens are referable to section A^1 of the above synopsis. One conforms to B^2 , while two fall under B^1C^2 , which contains everything not referable to *tenuis*, but having somewhat longer abactinal and marginal spinelets than are found in the general run of forma *validus* with long actinal spines (A^1)—about as in Koehler VII 1, where the spinelets are obviously longer than XL 7 and shorter than XL 6 (*tenuis*).

The three specimens from St. 368 (363 m.) are of interest since one of them is the only example of forma *tenuis* in the collection; another is conceivably an intergrade; while the third is certainly not *tenuis* since it falls under A^2 of the synopsis, yet has longer, slenderer rays than the typical form of *validus*. There is great variation in the size of the madreporite in all phases of *validus*. The figure of *tenuis* given by Koehler (1920, pl. 40, fig. 3) shows a large plate. In the Bouvet Island specimen it is about one-half this size. A few specimens of undoubted forma *validus* have the madreporite as large as in this figure of *tenuis*.

Our largest specimens are from St. 370, South Sandwich Island. Of these the largest has R 70 mm., r 25 mm., br 25–28 mm., breadth of madreporite 11 mm. The rays are rather slender and obviously long, the rays being longer in proportion to disk than in Koehler's figures of *tenuis*, which this specimen clearly is not. The smallest from St. 370 has R 49 mm., r 22 mm., br 26 mm., breadth of madreporite, 3.5 mm. This specimen is a typical forma *validus* with swollen disk, small, well-spaced paxillae, the superomarginals of interbrachial region having about 12 spinelets. The mouth angles are worthy of close attention, for *each* has 3 "teeth", the normal recurved median, and a shorter one on either side, such as characterize Koehler's "*Epidontaster*" and

"*Tridontaster*". Not all the lateral teeth have a hyaline tip protruding through the sheath.

In *Odontaster validus* there is much variation in the armature of the mouth-plates as regards the size of the unpaired hyaline spine and of the *innermost* of the 2 or 3 suborals which stand on either side of this hyaline tooth.

(1) The unpaired spine may be missing (St. MS 6) and the "bud" of a new one appears in its place. This suggests a strenuous use for the teeth during which they are occasionally broken. The laterals have not superseded it.

(2) In one angle (St. 164) there are 2 subequal sharp, glassy tipped teeth, as in the genus *Asterodon*; the same variation occurs in *Odontaster penicillatus forma grayi*. From its position I would say that one is the true unpaired tooth and the other a suboral spine.

(3) In one angle there are 2 enlarged teeth which are certainly the innermost suboral spines. The median tooth appears to have been broken and never to have regenerated. The 2 teeth are blunt, recurved, and hardly hyaline at tip. The other 4 normal mouth angles have only the tip of unpaired tooth emerging from its sheath, while in 2 of these mouth angles the inner suborals are conspicuously enlarged and needed only a little time to become "hyaline" (St. WS 62).

(4) This last feature is not so important as it would seem since a considerable number of specimens (St. 164, St. MS 10) have the sacculus persisting at the end of some, or all, of the 5 normal teeth which thus have no exposed hyaline tip (see Koehler's genus "*Metadontaster*").

(5) Finally, there is great diversity in the size and shape of the unpaired tooth. They may be thick, broad, and only half as long as the median suture separating mouth-plates; or short and slender; or slender, and of various lengths to a trifle more than three-fourths that of median suture. The truncate base of spine is at the inner end of mouth-plates (M 71) or spaced from the end. These variations in the size and shape of teeth may occur at the same station (164).

It is obvious from the foregoing paragraphs that there is considerable latitude of variation. In spite of Koehler's resuscitation of his *O. tenuis* (1920, p. 232) I believe he was correct in his earlier view (1912, p. 68) when he reduced it to a variety of *validus*.

COLOUR NOTES (Ridgway's nomenclature). St. 164, Bordeaux purple (apparently no distinction between specimens of A^1 and A^2 of synopsis). St. 173, 22 specimens, pansy purple; 2 specimens, apricot orange. Of these two exceptions one belongs in A^1C^3 , the other in A^1B^2 of synopsis. St. 1959, very dark brown, almost black, with whitish spinelets dorsally and yellowish white ventrally.

TYPE LOCALITY. Antwerp Island, Palmer Archipelago (First Charcot Expedition).

DISTRIBUTION. Circumpolar, north to South Georgia (including Shag Rocks) and Bouvet Island; shore to 653 m.

Kochler in his several memoirs lists numerous stations, including (1908, p. 540) "îles Falkland, 5-20 brasses". I believe this to be due to a misplaced label. The locality is unlikely. The extensive work of R.S.S. 'William Scoresby' on the Falkland Plateau has failed to provide a single specimen of *validus*, but numerous examples of other species of *Odontaster*.

Odontaster penicillatus (Philippi)

Goniiodiscus penicillatus Philippi, 1870, p. 268.

Calliderma grayi Bell, 1881, p. 95, pl. 8, fig. 5.

Pentagonaster paxillosus Bell, 1881, p. 95.

Gnathaster pilulatus Sladen, 1889, p. 292, pl. 57, figs. 5-7.—Verrill, 1899, p. 205.

Gnathaster grayi Sladen, 1889, p. 286.—Verrill, 1899, p. 205.

Asterodon pedicellaris Perrier, 1891, p. 135, pl. 8, figs. 1a, 1b.

Odontaster grayi Bell, *Proc. Zool. Soc. Lond.*, 1893, p. 261.—Ludwig, 1905, p. 48, pl. 5, figs. 6-9.—

Fisher, 1911, pp. 154, 158.

Odontaster pedicellaris Bell, 1893, p. 262.

Gnathaster pedicellaris Perrier, 1894, pp. 2, 244.—Verrill, 1899, p. 205.

Odontaster meridionalis Leipoldt, 1895, p. 620, pl. 31, fig. 8f, pl. 32, fig. 8a-e, g.—Meissner, 1896, p. 93.

Odontaster penicillatus Meissner, *Zool. Anzeiger*, xxi, 1898, p. 394.—Ludwig, 1905, p. 46, pl. 5, figs. 4, 5.

Gnathaster penicillatus Koehler, 1920, p. 194.

Peridontaster grayi Koehler, 1920, p. 194, pl. 39, figs. 5, 6.—1923, p. 86, pl. 11, figs. 1-4; pl. 12, figs. 9, 10.

St. 652. Burdwood Bank, 169-171 m., 1 specimen.

All the following stations 'William Scoresby'.

73. Falkland Islands, 51° 01' S, 58° 54' W, 121 m., fine dark sand, 1 f. *penicillatus*.

81. 8 miles north-west of North Island, West Falkland Island, 81-82 m., sand, 4 f. *penicillatus*, 1 f. *grayi*.

83. 14 miles south-west of George Island, East Falkland Island, 137-129 m., fine green sand and shell, 17 f. *grayi*.

84. 7½ miles south-west of Sea Lion Island, East Falkland Island, 75-74 m., shells and stones, 4 f. *penicillatus*.

85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., and shells, 6 f. *penicillatus*, 2 f. *grayi*.

86. Falkland Islands, 53° 53' 30" S, 60° 34' 30" W, 151-147 m., shell and stones, 16 f. *grayi*, 4 intergrades.

93. West Falkland Island, 51° 51' S, 61° 30' W, 133-130 m., grey sand, 1 f. *grayi*, 1 intergrade.

97. Falkland Islands, 49° 00' 30" S, 61° 58' W, 146-145 m., 1 intergrade.

98. Falkland Islands, 49° 54' 15" S, 60° 35' 30" W, 171-173 m., 1 f. *penicillatus*.

99. Falkland Islands, 49° 42' S, 59° 14' 30" W, 251-255 m., fine dark sand, 2 f. *grayi*.

225. Falkland Islands, 50° 20' S, 62° 30' W, 162-161 m., green sand, shells, pebbles, 3 f. *grayi*.

244. Falkland Islands, 52° S, 62° 42' W, 253-247 m., sand and mud, 1 intergrade.

246. Falkland Islands, 52° 25' S, 61° W, 267-208 m., coarse green sand and pebbles, 3 f. *grayi*.

248. Falkland Islands, 52° 40' S, 58° 30' W, 210-242 m., fine green sand, pebbles, shells, 1 f. *penicillatus*, 1 intergrade.

756. Falkland Islands, 50° 54' 39" S, 59° 58' W, 118-104 m., 1 f. *penicillatus*.

765. Off Cape Dos Bahias 45° 07' S, 60° 28¼' W, 113-118 m., 1 f. *grayi*.

776. Off Golfo San Jorge, 46° 18½' S, 65° 02½' W, 107-99 m., 1 f. *penicillatus*.

804A. Falkland Plateau, 50° 22¾' S, 62° 49' W, 150-143 m., 1 f. *grayi*.

804B. Near 804A, 143-150 m., 1 f. *grayi*.

805. Falkland Plateau, 50° 10¼' S, 63° 29' W, 148 m., 1 f. *penicillatus*.

824. Falkland Islands, 52° 29¼' S, 58° 27¼' W, 146-137 m., 4 f. *grayi*.

825. Falkland Islands, 50° 50' S, 57° 15' W, 135 m., 3 f. *grayi*.

841. Falkland Islands, 54° 11¾' S, 60° 21½' W, 109-120 m., 1 f. *grayi*.

848. Falkland Plateau, 50° 37½' S, 66° 24' W, 115-117 m., 1 f. *penicillatus*.

871. 53° 16' S, 64° 12' W, 336-341 m., 1 f. *penicillatus*, 1 f. *grayi*.

As detailed under "Remarks", *Odontaster penicillatus* appears to be a composite of several formae. The problem is complicated by the absence of figures of Philippi's type specimen whereby the type form may be identified. In the absence of this information, the type form is assumed to be that described and figured by Sladen as *Gnathaster pilulatus*. As a matter of fact it may well be one of three others analysed in the subjoined key. Similarly, the type form of *Odontaster grayi* is assumed to be that with narrower superomarginals, as figured by Koehler, 1912, pl. 11, figs. 1, 2.

The following synopsis may be of aid in distinguishing the principal varieties, though this will not be easy without an extensive series of specimens for comparison.

- a*¹. Forma *penicillatus*. Form stellate, the breadth of ray at base equal to or less than the length measured along side; marginal plates 11–21 according to size of specimen; see "Remarks".
 - b*¹. Central spinelets of paxillae conspicuously larger than marginal spinelets; paxillae distinctly spaced.
 - c*¹. Superomarginal plates narrow (Sladen's figure of *pilulatus*). St. WS 84.
 - c*². Superomarginal plates patently heavier and broader than in Sladen's figure of *pilulatus*. St. WS 776.
 - b*². Central spinelets of paxillae not conspicuously larger than median spinelets, usually slender; paxillae not spaced.
 - c*¹. Superomarginal plates slightly narrower to slightly broader than in Sladen's figure of *pilulatus*; breadth of proximal plates equal to length of $1\frac{1}{4}$ – $1\frac{3}{4}$ plates. St. WS 98, WS 756A.
 - c*². Superomarginal plates broader and encroaching more upon paxillar area; breadth equal to length of 2 – $2\frac{1}{4}$ plates. St. WS 848. Here also would go 8 specimens with broad, rather coarsely granulate, superomarginals; form stellate; superomarginals 13–15. They are more stellate than the general run of *grayi*, yet appear more closely allied to that form on account of the low number of marginals. The body form is that of *penicillatus*. In the register of specimens they are entered as "intergrades".
- a*². Forma *grayi*. Form pentagonal to stellate-pentagonal; rays broader at base than length along the side; marginal plates upward of 17; see "Remarks".
 - b*¹. Superomarginal plates narrow (Koehler, 1912, pl. 11, fig. 2) to medium broad. These intergrade with *b*²; usually but not invariably larger specimens. St. WS 83, WS 86.
 - b*². Superomarginal plates broad (Koehler, 1912, pl. 12, fig. 9).
 - c*¹. Superomarginal and to a less extent paxillar spinelets granuliform in appearance; actinal spinelets coarser; specimens usually small, although the largest specimen of *f. grayi* (R 42 mm., St. WS 765) falls here.
 - c*². Superomarginal spinelets slender, close-set three times as long as thick; paxillae small, widely spaced, with slender delicate spinelets; actinal spinelets long and slender. One specimen, arcuately stellate-pentagonal, R 42 mm., 15 superomarginals, St. WS 825. This specimen has 3 teeth to each mouth angle and falls in Koehler's *Epidontaster* but appears to be a variant of forma *grayi*.

REMARKS. The extensive series of specimens has revealed a very considerable range of variation. Some of these specimens satisfactorily bridge the gap supposed to exist between *Odontaster penicillatus* Philippi (*O. pilulatus* Sladen) and *O. grayi* Bell. In the species known as *grayi* the body shape ranges from pentagonal, usually slightly to decidedly "arcuate" (Koehler, XI, 2¹), to broadly stellato-pentagonal, there being,

¹ These references are to Koehler, 1912, pls. 11 and 12; Koehler, 1920, pl. 39; Sladen, 1889, pl. 57.

sometimes an angle instead of a curve at the interradial plate (Koehler, XII, 9 and 10). The superomarginal plates run as high as 17 and are conspicuously broad, or only slightly broader than long. The best figure of *penicillatus* is that of Sladen (LVII, 5) in which the shape is broadly stellate and the superomarginals rather narrow. Ludwig's (1905, pl. 5, fig. 4) figure of *penicillatus* is of a very young specimen (R 4 mm.) and useless for estimating the appearance of the adult. His figures of *grayi* (pl. 5, figs. 6-9) represent the two varieties illustrated by Koehler, but at a younger stage.

There are other major variations not illustrated. On the assumption that *grayi* is represented by the pentagonal specimens with fewer superomarginals, and *penicillatus* by examples of a stellate shape with more numerous superomarginals, the following analytical table was made of all except very young examples. The columns are to be read from top to bottom. The specimens are arranged in columns A-G in groups according to the number of superomarginals to a ray (excluding interradial plate). The third, fourth, fifth transverse columns attempt to differentiate form of body. Stellato-pentagonal indicates that there is a broad angle at the interradius as in Koehler's fig. XI, 9, while the side of the ray is fairly straight. The breadth of the ray at interradius must be *greater* than its length measured along the side. In stellate specimens (transverse column 5) the two dimensions are equal or the length is the greater (Sladen, LVII, 5).

Column ...	A	B	C	D	E	F	G
1. No. of superomarginal plates	10	11-12	13	14	15	16-17	20-21
2. Range in length of R in mm.	10-22	13-36	14-49	24-38	25-42	24-46	42-50
3. No. of specimens pentagonal or arcuate pentagonal	8	13	5	2	0	0	0
4. No. of specimens stellato-pentagonal	2	7	6 ³	1	5 ⁶	3 ⁷	0
5. No. of specimens stellate	0	3 ¹	2	7 ¹	2	6	2
6. No. with broad marginals	9	16	6	4 ⁵	5	5 ⁸	1 ¹⁰
7. No. with narrow or medium supero-marginals	1	7 ²	7	6	2	4 ⁹	1 ¹¹
Total no.	10	23	13	10	7	9	2

¹ Three young *penicillatus*, R 13-14 mm., Sts. WS 81, 871.

² Largest arcuate pentagonal, R 23 mm., St. WS 85; 3 forma *penicillatus*, 4 f. *grayi*.

³ See notes; contains intermediate forms.

⁴ Four forma *penicillatus* and 3 broad-margined intergrades or stellate f. *grayi*.

⁵ One forma *grayi* and 2 intergrades or stellate f. *grayi*.

⁶ None of these is typical *grayi*; 1 (St. WS 248) is the heavy margined substellate form of *grayi*. The largest, R 42 mm., has 3 teeth.

⁷ Sts. WS 225, 248; not typical *grayi*.

⁸ Includes the 3 not typical *grayi*; 1 forma *penicillatus*, 1 intermediate.

⁹ Three similar to *pilulatus* of Sladen; 1 aberrant.

¹⁰ St. WS 848, R 50 mm., r 25 mm., R = 2r, forma *penicillatus*.

¹¹ St. WS 98, R 42 mm., r 22 mm.; superomarginals about as broad as in Sladen's figure of *pilulatus*.

With exception of 6 specimens in 4C there is no great difficulty in assigning to forma *grayi* all specimens in columns 3 and 4 and A-F. These range in size from R 10 to R 46 mm., and have 10-17 superomarginal plates. These specimens include the 2 (intergrading) subformae illustrated by Koehler (XI, 2 and XII, 9, 10), the extremes having narrow and broad superomarginal plates. The contour of these specimens varies from slightly arcuate pentagonal to deeply arcuate pentagonal and stellato-pentagonal, the last having, in all cases, broad superomarginals.

At the other extreme, the 2 specimens in 5G (one with broad, one with medium superomarginals) represent 2 of the 3 recognizable varieties of forma *penicillatus*. The third variety is represented by the type of "*Gnathaster pilulatus*".

Twenty-six remaining specimens are included in column 5, B-F, and in 4C. The 3 small specimens in 5B are young forma *penicillatus*. Two in 5C are just within the category of stellate and are forma *penicillatus*, the central paxillar spinelets being slenderer than in Sladen's figure (LVII, 5); Sts. WS 81, 84.

The 6 specimens in C4 (stellato-pentagonal, with 13 superomarginals) are of 3 sorts. One specimen (St. WS 85, R 19 mm.) is evidently "*pilulatus*" in spite of its few marginals. Two (St. WS 86, R 23 and 27 mm.) have the breadth of ray at base only a trifle greater than length on side. The marginals are broader, the pseudopaxillae more closely placed, and their central spinelets slenderer than in *pilulatus*. These specimens, captured with typical *grayi*, may be considered another forma or intermediates. (Three similar specimens with 14 superomarginals are listed in 5D.) Finally (in 4C) are 3 specimens (Sts. WS 83, 804, 652; R 20-32 mm.) with very heavy marginals and a more stellate contour than Koehler's fig. XII, 9. These may be considered a substellate phase of *grayi*, but are not at all typical of the form.

Of the 7 specimens in 5D (14 superomarginals) 4 are similar to Sladen's *pilulatus* (R 24-34 mm., Sts. WS 73, 84, 85). Three have broad superomarginals and are the same as the intermediates mentioned in the preceding paragraph.

The 2 specimens in 5E are similar to Sladen's *pilulatus* (Sts. WS 81, 85).

The 6 specimens falling in 5F include 4 forms: 3 specimens (R 24-46 mm., Sts. WS 84, 85, 776) are close to Sladen's *pilulatus*, although 2 have somewhat broader superomarginals; 1 (R 32 mm., St. WS 805) has broad superomarginals, slender pseudopaxillar spinelets and is similar to the broader margined example of *penicillatus* in 5G; 1 of the two remaining specimens (R 35 mm., St. WS 756A) has coarse, granuliform spinelets, narrow marginals and large paxillae. It is possibly a variant of *pilulatus*. The other (R 34 mm., St. WS 244) has broad superomarginals with coarse granules and smaller, spaced pseudopaxillae, the short spinelets of which are noticeably less in diameter than the superomarginal granules. It is perhaps another of the problematical intermediates.

Ludwig's idea that *penicillatus* is a deeper water species than *grayi* is not borne out by the present material. Forma *grayi* was taken alone at 10 stations ranging in depth from 109 to 255 m. Forma *penicillatus* alone was taken at 6 stations ranging in depth from 74 to 148 m. They were taken together in hauls ranging in depth from 79 to 82 m.

Forma *penicillatus* and a problematical intergrade were taken as deep as 242 m. There is probably no effective difference in the bathymetrical distribution of the two forms.

Koehler (1920, pp. 191, 195) has based a new genus *Epidontaster* upon *E. pentagonalis* (*loc. cit.* p. 235, pl. 39, figs. 3, 4, 8; pl. 41, figs. 9-11) a new species, which is probably a variant of *Odontaster meridionalis* characterized by having 3 hyaline teeth to each mouth angle. The presence of a smaller hyaline tooth on either side of the median tooth is a normal variation in *Odontaster*. The innermost suboral spine on either side of the median tooth varies considerably in size. When it reaches a certain length it tends to bend away from the mouth angle and in extreme cases to acquire a blunt or pointed hyaline tip. I have noted 3 hyaline teeth in 8 specimens of forma *grayi*, ranging in size from R 14 mm. to R 42 mm., from Sts. WS 83, 84, 86, 246, 824, 825. Numerous others have the lateral inner suboral spine simply enlarged. In forma *penicillatus* 5 specimens from Sts. WS 73, 85, 756A have such enlarged laterals, which can scarcely be called hyaline.

Odontaster crassus Fisher (1911, p. 54, pl. 29, figs. 1-4; pl. 56, fig. 6), coast of California, 43-284 fathoms, resembles a stellate forma *grayi*. The marginal plates are fewer and much more massive than in the heaviest margined specimens of *grayi*. In *crassus* the superomarginals are 7 or 8, while in a comparable specimen of *grayi* they are 10-12. In *crassus* the primary interr radial plates are conspicuously larger than the other abactinal plates which is not the case in *grayi*. In *crassus* the actinal spines are much coarser than in any of the numerous examples of *grayi*.

Genus *Acodontaster* Verrill

Gnathaster pars, Sladen, 1889, p. 285.

Acodontaster Verrill, 1899, p. 204. Type *Gnathaster elongatus* Sladen.

Heuresaster Bell, 1908, p. 8. Type *H. hodgsoni* Bell.

Pseudontaster Koehler, 1912, p. 85. Type *Ps. marginatus* Koehler.

Metadontaster Koehler, 1920, pp. 191, 193. Type *M. waitei* Koehler.

Tridontaster Koehler, 1920, pp. 191, 193. Type *T. laseroni* Koehler.

Odontaster pars, authors.

Acodontaster elongatus (Sladen)

Gnathaster elongatus Sladen, 1889, p. 288, pl. 19, figs. 5, 6; pl. 48, figs. 1-4; pl. 49, figs. 5-10.

Acondontaster elongatus Verrill, 1899, p. 204.

Odontaster cremeus Ludwig, 1903, p. 21.—Koehler, 1912, pp. 81, 198, pl. 3, figs. 1, 3.

Acodontaster cremeus Koehler, 1920, p. 199, pl. 45, figs. 1-4, 7-12; pl. 47, figs. 1, 3, 4; pl. 69, figs. 3, 4.

Pseudontaster stellatus Koehler, 1920, p. 210, pl. 50, figs. 1-7; pl. 70, fig. 2 (forma).

Pseudontaster moderatus Koehler, 1923, p. 89, pl. 11, figs. 6, 7 (Shag Rocks).

St. 123. Off mouth of Cumberland Bay, South Georgia, 230-250 m., grey mud, 1 specimen.

St. 148. Off Cape Saunders, South Georgia, 132-148 m., grey mud and stones, 1 specimen.

St. 149. Mouth of East Cumberland Bay, South Georgia, 220-234 m., mud, 1 specimen (R 104 mm., r 36 mm.).

St. 170. Off Cape Bowles, Clarence Island, 63° 17' 20" S, 59° 48' 15" W, 200 m., mud, stones, gravel, 3 young specimens.

St. 181. Schollaert Channel, Palmer Archipelago, 160-330 m., mud and stones, 1 specimen.

St. 1564. Marion Island, 46° 36.5' S, 38° 02.3' E, 108-113 m., 1 specimen.

The largest specimen, St. 123, has R 95 mm., r 34 mm., br 40 mm. In shape it is intermediate between Sladen's figs. 1 and 2, pl. 48, and considerably larger than fig. 1 which has R 66 mm. The specimen from St. 181 has R 70 mm., r 27 mm., br 28–29 mm., and is like fig. 1 except that the abactinal surface is much inflated and the pseudopaxillae more widely spaced. The example from Marion Island (R 49 mm., r 20 mm.) is closely similar to Sladen's fig. 3, pl. 48.

It is difficult to ascertain whether *Acodontaster cremeus* Koehler is Ludwig's species, for the latter was based upon an obviously immature and inadequate specimen (R 18.5 mm.) collected by the 'Belgica' in 450 m., 71° 18' S and 88° 02' W. It is figured by Koehler, 1912, pl. 3, figs. 1 and 3, and 1920, pl. 47, fig. 1.

Koehler's *cremeus*, ranging in size from R 14 to 23 mm., is probably the young or a depauperate form of *elongatus*. In his description of *Acodontaster granuliferus*, Koehler emphasizes its similarity to *cremeus*. Now, as detailed below, *granuliferus* seems to be one of the manifestations of a race of *elongatus* which lives on the Falkland Plateau. The similarity of *cremeus* and *granuliferus* is explicable on the assumption that they are corresponding formae of two races of *elongatus*.

Pseudontaster stellatus Koehler from 64° 32' S, 97° 20' E, 110 fathoms, was collected in the same haul as one of the specimens of *Acodontaster cremeus*. The species is based upon a single specimen having R 56 mm. The description of the species is therefore only a description of a specimen, which I believe to be the adult of Koehler's *cremeus*, and a form of *elongatus* with slightly narrower than typical marginal plates and somewhat shorter rays. The importance which Koehler places upon the inflation of the disk is difficult to explain since such variations are of no greater significance than a full stomach, swollen gonads, or an artefact of preservation. For instance, it may be produced by immersing a living specimen in fresh water. The Discovery specimen from St. 181 has an inflated disk. Koehler makes no mention of *Acodontaster elongatus* in his description of *stellatus*, since he was convinced that *Pseudontaster* constituted a natural group. Therefore the type of *Acodontaster* was naturally not in competition with *stellatus*.

The type of *Acodontaster capitatus* (Koehler), having R 20 mm., was taken in 254 m. near Adelaide Island (67° 43' S, 70° 45' 42" W), while 6 other specimens were dredged in 354 and 318 fathoms, at 66° 50' S, 142° 6' E and at 66° 55' S, 145° 21' E (off Adélie Land). The largest of these has R 55 mm., r 16 mm. It is rather obviously near *A. elongatus*, the principal differences being that *capitatus* has slightly slenderer and longer rays, narrower superomarginal plates, and coarser granules than the typical form. It is probably a high antarctic forma of *elongatus*. See Koehler, 1912, p. 82, pl. 6, figs. 5, 8, 9, 11; 1920, p. 195, pl. 44, figs. 1–10; pl. 45, figs. 5, 6.

TYPE LOCALITY. Not indicated by Sladen. Probably off Cumberland Bay, Kerguelen Island, 127 fathoms, greenish volcanic mud.

DISTRIBUTION. Circumpolar, Antarctic, north to Kerguelen, Heard, Marion Islands, and South Georgia.

Acodontaster elongatus granuliferus (Koehler)

(Plate I, figs. 1-6)

Asterodon Grayi, Perrier, 1891, p. 138.

Odontaster granuliferus Koehler, 1912, p. 77, pl. 6, figs. 7, 10.

Odontaster propinquus A. H. Clark, 1917, p. 7.

Acodontaster granuliferus Koehler, 1920, p. 192.

Odontaster glaber Barattini, 1938, p. 22.

DIAGNOSIS. Differing from typical *elongatus* in having shorter rays, broader disk, fewer marginal plates, the superomarginals sometimes thick, broad, and convex. Form stellate to arcuate stellato-pentagonal.

In the following list of localities *c* and *g* after the number of specimens signifies forma *ceramoideus* and forma *granuliferus*.

St. 652. Burwood Bank, 171-169 m., 1 *c*.

St. WS 80. Falkland Islands, 50° 57' S, 63° 37' 30" W, 152-156 m., fine dark sand, 2 *g*.

St. WS 81. 8 miles N 11° W of North Island, West Falkland Island, 81-82 m., sand, 1 *g*.

St. WS 83. 14 miles S 64° W of George Island, East Falkland Island, 137-129 m., fine green sand and shell, 2 *c*, 1 intergrade.

St. WS 84. 7½ miles S 9° W of Sea Lion Island, East Falkland Island, 75-74 m., shells and stones, 1 *g*.

St. WS 85. Falkland Islands, 52° 09' S, 58° 18' W, 79 m., sand and shells, 2 *g*.

St. WS 93. West Falkland Island, 51° 51' S, 61° 30' W, 133-130 m., fine dark sand and stones, 2 *g*, 2 *c*.

St. WS 98. 49° 54' 15" S, 60° 35' 30" W, 171 m., 2 *g*.

St. WS 246. Falkland Islands, 52° 25' S, 61° 00' W, 267-208 m., coarse green sand and pebbles, 1 *c*.

St. WS 248. Falkland Islands, 52° 40' S, 58° 30' W, 210-242 m., fine green sand, pebbles, 2 *c*.

St. WS 793. 45° 53' S, 61° 35' W, 108-111 m., 1 *c*.

St. WS 796B. 47° 53½' S, 63° 32½' W, 108-112 m., 1 *g*.

St. WS 799A. 48° 04½' S, 62° 48' 07" W, 141-137 m., 1 *c*.

St. WS 804. 50° 22¾' S, 62° 49' W, 150-143 m., 1 *g*.

St. WS 807. 49° 50½' S, 65° 03' W, 125-126 m., 1 *c*.

St. WS 815. 51° 51¾' S, 65° 44' W, 132-162 m., 1 *g*.

St. WS 823. 52° 14½' S, 60° 01' W, 80-95 m., 1 *g*.

St. WS 824. 52° 29¼' S, 53° 27¼' W, 146-137 m., 1 *g*.

St. WS 825. 50° 50' S, 57° 15¼' W, 135 m., 1 *g*, 1 *c*.

St. WS 871. 53° 16' S, 64° 12' W, 336-841 m., 1 *g*.

Acodontaster elongatus, in a fairly typical form, ranges to South Georgia, but on the Falkland Plateau is represented by a race which occurs in two formae. The extremes of variation might well be considered to represent distinct species if they were not connected by numerous intergrading specimens. This variation closely parallels that noted under *O. penicillatus*, in which occurs the same transition from a stellate form with narrower, more numerous marginals (e.g. *Odontaster penicillatus* forma *penicillatus*) to one arcuately pentagonal with short rays and broader, convex, fewer marginal plates (e.g. forma *grayi*).

Koehler details the history of the type of his *granuliferus*, which was identified by Perrier with Bell's *Calliderma grayi*, and which is now in the Museum d'Histoire Naturelle. It is clearly the form designated below as forma *granuliferus* and is nearest typical *elongatus*. In the extreme form, such as the type illustrated by Koehler, the granular abactinal surface passes without any very perceptible change to that of the superomarginals which form a rounded bevel to the margin and are not thick when viewed from the side. The abactinal plates have practically no tabulum—only a convex surface covered by round-topped to subtruncate, crowded, 4- or 5-sided granules (e.g. specimens A, B, C of table). Then the superomarginals become more convex, are generally broader than in A, B and C, and the margin of ray is thicker (D, E, F of table). These specimens have 21 or 22 superomarginals in contrast to 26 in A and B (C is a smaller specimen). A to F have been grouped under forma *granuliferus*.

Then with no hiatus and still with broad superomarginals, the rays gradually shorten and the marginals become fewer (G to K of table). The large specimen G with R 59 mm. has 19 superomarginals while B, with R 55 mm., has 26. Specimen K is the most extreme, with 13 broad convex superomarginals. This is the type of forma *ceramoideus*. A comparable specimen of forma *granuliferus* has 20 superomarginals, about half as wide.

Specimen	St. WS	R mm.	r mm.	Superomarginal plates
A	81	69	32	26
B	823	55	25	26
C	85	39	18	20
D	804	54	27	21, 22
E	796 ^B	52	27	22
F	825	57	27	22
G	799 ^A	59	34	19
H	83	42	24	16
I	248	36	21	15
J	652	37	23	15
K	246	33.5	20	13

The photographic figures, in connection with two of the type (Koehler, 1912), must suffice to elucidate the two formae which are here formally noticed in order to emphasize the interesting parallel with *Odontaster penicillatus*.

Forma *granuliferus* Koehler (Plate I, figs. 1, 2).

DIAGNOSIS. Near *elongatus* but with shorter rays, broader disk, fewer and shorter marginal plates; superomarginal plates wider than long with plane abactinal surface, the series forming a rounded bevel to margin of body, or else slightly convex, forming a convex border; form stellate.

Odontaster propinquus Clark belongs to this forma. The type, which I have examined, was taken at Albatross St. 2771, 51° 34' N, 68° W, 50.5 fathoms, grey sand, bottom temperature, 49.4° F.

Forma ceramoideus nov. (Plate I, figs. 3, 5, 6).

DIAGNOSIS. Differing from extreme examples of forma *granuliferus* in the arcuate, stellate-pentagonal shape, and in having fewer, generally broader superomarginal plates, which are always more or less convex and constitute, with the similar inferomarginals, a thick frame enclosing the body.

Type St WS 246.

REMARKS. The smallest specimen of forma *granuliferus* has R 12.5 mm. and about the same form as the adult. It would probably be difficult to distinguish from the young of typical *elongatus*. There are 13 superomarginals, the same as in specimen K having R 33.5 mm. The smallest specimen of *ceramoideus* has R 8.5 mm., 8 superomarginals and a stellato-pentagonal form. It was taken at St. WS 825 along with specimen F, which is something of an intergrade as regards the fewer, thick marginals (but is stellate in form).

Forma ceramoideus is easy to confuse with *O. penicillatus* forma *grayi* with which it is sometimes associated. In *ceramoideus* (and *granuliferus*) the actinal spinelets of the oral angles are gradually transformed into polygonal *granules* toward the inferomarginal plates so that the actinal plates, for some distance back from the inferomarginals, are armed with granules similar to those of the inferomarginals. In *grayi* all the actinal plates are spinulose, and the inferomarginal armature is spinulose rather than granulose; the abactinal plates are distinctly tabulate and are, in fact, low paxillae.

TYPE LOCALITY OF *ACODONTASTER ELONGATUS GRANULIFERUS*. 53° 13' S, 68° 31' W (east coast of Tierra del Fuego), 97 m. (Mission Scientifique du Cap Horn, 1882-3).

DISTRIBUTION. Falkland Plateau; Cape region; north to Uruguay where *A. glaber* (Barattini) may constitute a recognizable race.

Acodontaster conspicuus (Koehler)

Pseudontaster conspicuus Koehler, 1920, p. 202, pl. 42, figs. 1-7; pl. 43, figs. 1-10; pl. 70, fig. 1.—1923, p. 88, pl. 13, figs. 4-6.

Acodontaster elongatus var. *abbreviatus* Koehler, 1923, p. 81, pl. 10, figs. 1-3 (South Georgia, 24-52 m.).

St. 42. Off mouth of Cumberland Bay, South Georgia, 120-204 m., 2 specimens.

St. 123. Off mouth of Cumberland Bay, South Georgia, 230-250 m., grey mud, 1 specimen.

St. 148. Off Cape Saunders, South Georgia, 132-148 m., grey mud and stones, 1 specimen.

St. 149. Mouth of East Cumberland Bay, South Georgia, 200-234 m., mud, 1 specimen, R 70 mm., r 30 mm.

St. WS 865. 50° 03' S, 64° 14' W, 126 m., 1 specimen, R 82 mm., r 36 mm.

This species has been figured and described in detail by Koehler. It is characterized by curious pedicellariae composed of 3 or 4 enlarged, flat-topped granules, which do not protrude beyond the other granules, except on the actinal plates near the oral angle. Here the actinal granules gradually lengthen into spinelets and the valves of the pedicellariae likewise lengthen. They sometimes form a conical fascicle of 3 or 4 pointed thickened spinelets; or retain their characteristic shape, with longer valves (Koehler, 1920, pl. 43, fig. 9).

Acodontaster waitei also has these pedicellariae and so closely resembles *conspicuus* in most respects that the two forms may easily be confused. Whether they are 2 species, or forms of one, will require more material to determine. *A. conspicuus* is characterized by a large unpaired tooth with a well-developed hyaline tip; while in *waitei* the unpaired tooth is inconspicuous, compressed, the hyaline point only slightly or not at all apparent.

It seems to me to be probable that the two specimens (G, H) which Koehler names variety *inarmata* (1920, p. 210, pl. 43, figs. 6, 7) may well be the young of some forma of *A. elongatus*.

Acodontaster elongatus var. *abbreviatus* Koehler, from Cumberland Bay, South Georgia, 24–52 m., was based upon a single immature specimen (R 22 mm.), in which the rays are relatively shorter than in the adult. Pedicellariae characteristic of *A. conspicuus* are present on the abactinal, superomarginal, and inferomarginal plates, while there is a conical fasciculate pedicellaria, composed of 4 spines, at the oral angle of each actinal area. A specimen with R 36 mm. from St. 42 has an identical distribution of the same kinds of pedicellariae, there being 2 or 3 fasciculate pedicellariae near the oral angle. Their valves are about twice as broad as the adjacent spines. As the animal grows the valves of all the pedicellariae increase in breadth more rapidly than do the surrounding granules, so that they are relatively larger in old specimens.

TYPE LOCALITY. St. 1 (Australasian Antarctic Exp.) 66° 50' S, 142° 06' E, 354 fathoms.

DISTRIBUTION. Off Adélie Land, 25–354 fathoms; off Graham Land, 150 m.; South Georgia, 24–250 m. If the specimen from St. WS 865 is correctly labelled, Falkland Plateau is the northern limit.

Acodontaster waitei (Koehler)

Metadontaster waitei Koehler, 1920, p. 219, pl. 46, figs. 1–6; pl. 47, figs. 5, 6; pl. 48, fig. 8; pl. 49, figs. 1–3, 19; pl. 71, figs. 1, 2.

St. 181. Schollaert Channel, Palmer Archipelago, 64° 20' S, 63° 01' W, 160–335 m., mud, 1 specimen (R 75 mm., r 29 mm.).

This is probably a form of *A. conspicuus*, which it closely resembles in all characters except that of the specialized oral spine and in having spinose conical fasciculate pedicellariae on the first few adambulacral plates. The tooth is smaller, and narrower at the base, than in *conspicuus*. It is compressed, and instead of lying close along the median oral suture, stands erect. The tip is covered by the integument or else only a very small hyaline portion protrudes. The actinal pedicellariae are in no wise different from those of *conspicuus*, as may be seen from Koehler's figure (1920, pl. 46, fig. 2); but they are more numerous in our example since the series adjacent to the adambulacral plate extends for a third to half the length of the furrow (10–20 pedicellariae). In addition, smaller pedicellariae occur on the proximal inferomarginal plates (absent in Koehler's specimens) but there are none on the abactinal surface. These inferomarginal pedicellariae are identical in form with those of *conspicuus*.

To make this form the type of a new genus on the strength of its small tooth is to ignore the sum total of the other characters. The highly special pedicellariae in particular are almost signboards to declare the close kinship of *conspicuus* and *waitei*. This is further supported by the skeletal structure and integumentary armature.

Koehler's type was taken in the same haul with *A. conspicuus*.

TYPE LOCALITY. St. 1, Australasian Antarctic Exp., 66° 50' S, 142° 06' E, 354 fathoms.

DISTRIBUTION. Adélie Land, and Antarctic Archipelago, to 354 fathoms. Note: the specimen recorded by Koehler from 110 fathoms off Queen Mary's Land (1920, p. 225, pl. 49, figs. 1-3) is perhaps a definitely distinct forma.

Acodontaster hodgsoni (Bell)

Heuresaster hodgsoni Bell, 1908, p. 8, pl. 3.

Tridontaster laseroni Koehler, 1920, p. 214, pl. 47, figs. 7-10; pl. 48, figs. 1-7; pl. 69, fig. 5.

St. 42. Off mouth of Cumberland Bay, South Georgia, 120-204 m., 1 specimen (R 74 mm., r 31 mm.).

Koehler has described and figured this species in great detail. It is regrettable that his name must be replaced by that of Bell who has furnished a figure of the actinal aspect. Otherwise the species could not be identified by Bell's vague description, which is also misleading, since he refers *Heuresaster* to the Poraniidae!

In addition to the Discovery specimen I have examined a slightly larger one from the British Museum labelled St. 316, Terra Nova, 353-55. Both agree in detail with Koehler's description, even to the actinal fasciculate pedicellariae (Koehler, 1920, p. 217, pl. 47, figs. 7, 9).

Other than having accessory "teeth", this species is an *Acodontaster* with small marginal plates of the type of *A. conspicuus*. In the Discovery specimen there are 2 subequal accessory spines on either side of the median tooth and these have little or no hyaline point. In the Terra Nova example three mouth angles have also this second accessory spine without a hyaline tip, while in the first accessory a little of the hyaline point is exposed.

Now *A. conspicuus* from St. 42 (as well as from Sts. 149 and WS 865) may have 1 or 2 accessory teeth or spines, without a hyaline tip. As *A. hodgsoni* was taken along with this specimen of *A. conspicuus* from St. 42, it was at first believed to be a forma of *conspicuus*. But it lacks the characteristic pedicellariae. An example of *A. elongatus* from St. 181 has 2 (in one case 3) accessory teeth with a short hyaline tip.

The possession of 3 teeth is a normal variation in *Odontaster validus* and *O. penicillatus*. It is apparently of no greater value here, since there may also be 5 teeth to a mouth angle as readily as 3.

TYPE LOCALITY. McMurdo Sound, South Victoria Land, 2 fathoms.

DISTRIBUTION. Circumpolar. Koehler's specimens were taken off Queen Mary Land (92° to 97° E) 60-110 fathoms, and off Adélie Land, 25 fathoms.

Genus *Asterodon* Perrier

Asterodon Perrier, *Comptes rendus*, cv1, 1888, p. 765.—1891, p. 129. Type *A. singularis* (Müller & Troschel).—Verrill, 1899, p. 203.

Asterodon singularis (Müller & Troschel)

Goniodiscus singularis Müller & Troschel, *Arch. für Naturgesch.*, 1x, 1843, p. 116.

Asterodon granulosus Perrier, 1891, p. 132, pl. 11, figs. 4a, 4b.

Asterodon singularis Perrier, 1891, p. 134, pl. 13, figs. 3a, 3b.—Ludwig, 1903, p. 19.—1905, p. 40, pl. 5, figs. 1–3.—Koehler, 1923, p. 84.

Odontaster singularis Bell, *Proc. Zool. Soc. Lond.*, 1893, p. 262.—Leipoldt, 1895, p. 614 (list of references).—Meissner, 1896, p. 92, pl. 6, figs. 5, 5a (type), 6.—1904, p. 19.—Clark, 1910, p. 332, pl. 2, fig. 4.

St. WS 583. 53° 39' S, 70° 54½' W (Strait of Magellan), 14–78 m., 1 specimen, forma *granulosus*.

It is evident that there are two intergrading formae, paralleling those found in *Odontaster penicillatus* and *Acodontaster elongatus granuliferus*.

Forma *singularis*.

Form stellate, with well-developed rays. Marginal plates more numerous (upward of 18), not encroaching widely upon the abactinal and actinal surfaces. Granuliform pedicellariae present or absent.

Müller and Troschel's type has been figured by Meissner, 1896, pl. 6, figs. 5, 5a. Other figures are Perrier, 1891, pl. 13, figs. 3a, 3b; Ludwig, 1905, pl. 5, fig. 1; Leipoldt, 1895, pl. 31, fig. 7a–c; Clark 1910, pl. 2, fig. 4.

Forma *granulosus*.

Asterodon granulosus Perrier, 1891, p. 132, pl. 11, figs. 4a, 4b (Punta Arenas).

Form arcuately pentagonal, with short rays, marginals of both series fewer (upward of 12) and heavier, forming a broad margin to body. Pedicellariae present.

Both the specimen figured by Perrier and that by Ludwig (1905, pl. 5, figs. 2, 3) are young. The specimen from St. WS 583 has R 35.5 mm., r 21.5 mm. It is notable for the broad marginals, 12 to a ray (in addition to interradian marginal). The first 2–5 ambulacral plates have 2 furrow spines, the rest 1. The abactinal, marginal, and actinal plates carry (in the aggregate) numerous pedicellariae with 2–4 granuliform valves which do not rise above the general surface of the granules.

If this specimen is compared with the published figures of *singularis*, the supero-marginals appear to be at least twice as broad, while the ray is broader, shorter, and more obtuse.

TYPE LOCALITY. Chile. Type no. 754, Berlin Museum, *vide* Meissner, 1896.

DISTRIBUTION. Coasts of Tierra del Fuego, north along the west coast of South America to 20° S latitude; low tide to 80 m.

Family GONIASTERIDAE Verrill

Genus *Pseudarchaster* Sladen*Pseudarchaster discus* Sladen

Pseudarchaster discus Sladen, 1889, p. 110, pl. 19, figs. 1, 2; pl. 42, figs. 3, 4.

Astrogonium patagonicum Perrier, 1891, p. 125, pl. 13, figs. 2a, 2b (Beagle Canal).

St. WS 781. $50^{\circ} 30' S$, $58^{\circ} 50' W$, 148 m., 1 specimen.

St. WS 782A. $50^{\circ} 29\frac{1}{4}' S$, $58^{\circ} 23\frac{3}{4}' W$, 141–146 m., 1 specimen.

St. WS 805. $50^{\circ} 10\frac{1}{4}' S$, $63^{\circ} 29' W$, 148 m., 2 specimens.

St. WS 850. $51^{\circ} 18\frac{3}{4}' S$, $63^{\circ} 30\frac{1}{4}' W$, 57–166 m., 1 specimen.

The specimens are large compared to the type, R ranging from 55 to 60 mm., whereas the type has R 30 mm. The post-adambulacral fascioles described by Sladen are present. Along the *transverse* margins of the actinal plates adjacent to adambulacrals, the spinelets, which are smaller than those of the rest of surface, bend over the sutural groove and touch similar spinelets of adjacent plate, forming a crude pectinate pedicellaria. These are most apparent or best differentiated near the mouth plates, where each comb has about 7 spinelets. There is an unpaired pedicellaria at outer end of mouth-plates; and a similar co-operation is apparent between the outer marginal adambulacral spinelets and adjacent actinal intermediate spinelets, although these combs are not so regular as the transverse ones.

As in other species of *Pseudarchaster* of which a series is known, specimens may be divided into two groups. In the one the rays are shorter and the marginal plates are shorter and broader than in the other, but there is no significant difference in the number of marginal plates (34–35).

Astrogonium patagonicum Perrier seems to me to be specifically the same as *discus* and to be referable to the slender-rayed variety. On the right side of Perrier's fig. 2b one can see, with a lens, an indication of the pectinate pedicellariae. In his list of sub-Antarctic echinoderms, Koehler (1912, p. 211) lists both *Astrogonium patagonicum* and *Pseudarchaster discus* as peculiar to the Magellan fauna, although he was certainly aware that the generic names are synonymous.

The persistent misuse of *Astrogonium* in France is a curious case of misguided loyalty to Perrier who started the vogue by appropriating a name, which never had any status, for a group of species (*Pseudarchaster* and *Aphroditaster*) none of which was listed in the original description of *Astrogonium* (Müller & Troschel, 1842, p. 52) for the obvious reason that none was known in 1842. Yet in 1894, five years after *Pseudarchaster* was published with figures, Perrier substituted *Astrogonium*.

Müller and Troschel in their *System der Asteriden*, 1842, established *Astrogonium*, without type, for 4 described genera, now in current use, namely *Hippasteria*, *Goniaster*, *Pentagonaster*, *Tosia*. If one adopts the first species as type, then *Astrogonium* was a synonym of *Hippasteria* Gray, 1840; if the oldest generic name included in the group, then *Astrogonium* is a synonym of *Goniaster* Agassiz, 1835. As stated above, no species of

Pseudarchaster was known at this time. Hence it would seem fantastic even to consider *Astrogonium* in connection with *Pseudarchaster*. Perrier by the same logic transferred Gray's *Dorigona* to Sladen's *Nymphaster*; yet no species of *Nymphaster* was included in Gray's genus, and none was known until many years after *Dorigona* was described.

Two species obviously related to *discus* are *Ps. pectinifer* Ludwig, Galapagos Islands, 812 fathoms, and *Ps. dissonus* Fisher, Bering Sea to Oregon, 859–1064 fathoms. Both are large species, *dissonus* reaching R 170 mm. In *dissonus* the post-adambulacral fascioles have become true valvate pedicellariae of a definite specialized form (Fisher, 1911, p. 192, pl. 34, figs. 1–3; pl. 57, figs. 7, 7a). In *pectinifer* these pedicellariae are as in *discus*, but more developed on account of the larger size of the specimens. *Ps. pectinifer* lives in a temperature of 38.5° while *dissonus* has a known range of 35.8 to 37.3° F., far colder than the water at moderate depth in the Magellan region where typical *discus* is found.

TYPE LOCALITY. Challenger St. 307, Messier Channel, between the western coast of Chile and Wellington Island, 140 fathoms, blue mud.

DISTRIBUTION. Magellanic and Falkland region, 140–283 m.

Genus *Ceramaster* Verrill

Ceramaster patagonicus (Sladen)

Pentagonaster patagonicus Sladen, 1889, p. 269, pl. 46, figs. 3, 4; pl. 49, figs. 3, 4.

Ceramaster patagonicus Fisher, 1911, p. 214, pl. 37, fig. 4; pl. 38, figs. 1, 2; pl. 60, fig. 3.—Koehler, 1923, p. 94.

St. WS 76. 51° 01' S, 66° 31' 30" W, 110–113 mm., coarse dark sand, 1 specimen.

St. WS 80. 50° 51' S, 63° 37' 30" W, 152–156 m., fine dark sand, 10 specimens.

St. WS 225. 50° 20' S, 62° 30' W, 162 m., 1 specimen.

St. WS 243. 51° 06' S, 64° 30' W, 144–141 m., coarse dark sand, 2 specimens.

St. WS 801. 48° 26¼' S, 61° 28' W, 165 m., 1 specimen.

St. WS 804. 50° 22¾' S, 62° 49' W, 150–143 m., 1 specimen.

St. WS 805. 50° 10¼' S, 63° 29' W, 148 m., 1 specimen.

St. WS 813. 51° 35¼' S, 67° 16¼' W, 106–92 m., 1 specimen.

St. WS 848. 50° 37½' S, 66° 24' W, 115–117 m., 1 specimen.

St. WS 850. 51° 18¾' S, 63° 30¼' W, 1 specimen.

This very widely distributed species has been figured and described by Sladen and the writer. After examining the Discovery collection I am convinced that the specimens from the north Pacific are *patagonicus*. Some of the small differences which I noted between these specimens and Sladen's excellent figures disappear with a series of southern specimens in hand. The latter are about as variable as the north Pacific specimens. The largest example has R 63 mm., r 45 mm.

It is possible that Perrier's *Pentagonaster austrogranularis* (1891, p. 127, pl. 12, figs. 3a, 3b) may prove to be a small *patagonicus*. All specimens of *granularis* attributed to the north Pacific have turned out to be *patagonicus*. Perrier's 2 specimens came from New Year Sound, 340 m., well within the range of *patagonicus*.

TYPE LOCALITY. Challenger St. 313, near the Atlantic entrance to the Strait of Magellan, 55 fathoms, sand; bottom temperature 47·8° F.

DISTRIBUTION. Falkland Plateau, Burdwood Bank; Gulf of California; southern Alaska to southern part of Bering Sea; 55–245 fathoms.

Notioceramus gen.nov.

DIAGNOSIS. Resembling *Peltaster* Verrill in having the entire surface covered with granules and the abactinal plates of radial papular areas without an elevated tabulum; differing from *Peltaster* in having short adambulacral plates with 2 (1–3) coarse furrow spines and a shorter but heavier subambulacral spine, followed by 1 or 2 smaller tubercles; pedicellariae primitive, composed of 3 flattened granules.

Type *Notioceramus anomalus*.

REMARKS. The type species is represented by only one specimen. Its abactinal surface resembles that of *Peltaster micropeltus*¹ (Fisher), but there the resemblance ends, for in *micropeltus* the adambulacral plates are longer than broad, with a furrow series of 5 or 6 small spines (rather like those of *Ceramaster*) and 2 longiseries of small granules (3 or 4 in first series, 5 or 6 in the outermost). Abactinally there are rather numerous small upright two-jawed spoon-shaped pedicellariae about the size of the granules. The jaws are often curved.

The adambulacral armature of *Peltaster* is of the type of *Ceramaster*, in which there is typically a gradation in length from the furrow spines through 2 or 3 series of successively shorter granules to the actinal granulation. In *Notioceramus* the armature can more appropriately be compared to that of *Cladaster* and *Hippasteria*. In fact, the armature is similar to that of certain plates of *H. falklandica*, at about mid R, even to the form of the subambulacral spines, except that in the latter species unequal granules occupy the transverse and outer margins of the plates.

In *Progoniaster* Döderlein,² in which all the plates are granulated, the adambulacral armature is similar to that of *Peltaster*. The only specimen of *P. atavus* is probably immature.

Notioceramus anomalus sp.nov.

(Fig. D, 1–1e; Plate II, fig. 4; Plate IV, fig. 5)

DIAGNOSIS. General form pentagonal, produced into short slender rays; disk low, scarcely inflated, but rays convex dorsally; margins bevelled and rounded; entire animal covered with rather coarse, close-set granules; abactinal plates rather small, not tabulate, with 6–8 granules on plates of radial series, diminishing as to size, regularity, and number of granules toward margin; marginal plates 17; adambulacrals with 2 (proximally sometimes 3, distally usually 1) coarse furrow spines, a still heavier subambulacral,

¹ *Tosia* (*Ceramaster*) *micropelta* Fisher, 1906a, p. 1054, pl. 21, fig. 2; pl. 26, figs. 4, 4a; 313–800 fathoms, off Bird Island, Hawaiian Islands. This species was later assigned to *Peltaster* (Fisher, 1911, p. 205) but it is not typical, although it has numerous furrow spines and subambulacral granules.

² Döderlein, *Die Asteriden der Liboga-Expedition, Pentagonasteridae*, 1924, p. 61, pl. 17, figs. 3–3c.

and 1 or 2 tubercular granules on outer end of plate. R 35 mm., r 19 mm., br at inter-radius 21–22 mm., at middle of ray 10 mm.

DESCRIPTION. Abactinal plates not tabulate, though the radial and adradial have a convex surface, which gradually flattens on interrarial region, where surface of plates is flush with integument—if not distorted by drying. The midradial plates are superficially wider than long, not very regular, nor particularly neat and uniform in size. This series reaches terminal plate. The plates of either adradial series are even less regular, are irregularly oblong or squarish and the series ceases 1–3 superomarginals distant from end of ray. The other plates are quite irregular and do not form well-defined series. Midradial plates with 5–8 coarse, subspherical granules (the larger 0.4–0.5 mm. diameter) those of distal plates often in 2 transverse series; other plates with 3–6 granules, according to distance from margin; primary interradians and central with about 15 or 16 granules. Madreporic plate 2.5 mm. in diameter, its inner margin $\frac{1}{3}$ r from centre of disk.

The abactinal plates are irregular in outline and imbricate as indicated in the figure of the coelomic surface of proximal radial area. The carinal plates are slightly smaller than the adradials of the 2 series at either side. Beyond these 2 series the plates become very rapidly smaller and more closely imbricated as there are no papulae. On the narrow part of the ray the carinals are larger than the adradials and are accompanied at either side by a single series of small papulae. Proximally there are 4 irregular series of small papulae.

The granulation of abactinal surface decreases gradually in size from the radial line to margin of area. Superomarginal and inferomarginal granules successively slightly larger than the peripheral abactinal, while the actinal granules are still larger and more distinctly spaced. A thin skin envelops the granules.

Superomarginal plates 17, generally a little wider than long, forming a slightly rounded bevelled border to abactinal area, as do the inferomarginals to the actinal. These plates are not tabulate but are individually slightly convex. Distally there is no trace of central tubercles on either series.

Adambulacral plates about as wide as length of furrow margin. Furrow spines 2, coarse, compressed, prismatic, 1.5 plates long measured on furrow margin. Back of these is a single, subequal, broad, round-tipped spine often occupying entire length of plate and with its broad side to furrow. Outer margin with 1 or 2 compressed or prismatic tubercles intermediate in size between the large tubercle and actinal granules. The distal plates usually have a transverse series of 3 coarse spines, the median the thickest. The first 2 plates sometimes have 3 furrow spines.

Mouth-plates not convex; with long furrow margin carrying 5 spines like the adambulacral; a curved series of 4 suborals rather like the outermost adambulacral tubercle.

Two 3-valved pedicellariae are present, one on outer part of a first adambulacral plate, the other adjacent to outer end of a second plate (Fig. D, 1e). As the jaws are only slightly modified granules, flattened and somewhat excavated on the innerface, the pedicellariae are very primitive.

TYPE LOCALITY. St. 170. Off Cape Bowles, Clarence Island, 342 m., rock, 1 specimen.

Genus *Pergamaster* Koehler

Pergamaster Koehler, 1920, p. 237. Type *P. tessellatus* Koehler.

Koehler has made the curious error of describing the peripheral *granules* of the abactinal and marginal plates as small *plates*. He says, "Les plaques dorsales du disque, qui sont absolument nues, sont plates, assez grandes et sont séparées par *des plaques très petites* ordinairement disposées sur deux rangs. Des plaques semblables et toujours de très petite taille, séparent les plaques marginales dorsales et ventrales successives, et séparent également chaque rangée l'une de l'autre." These, of course, are not secondary plates as the description implies but the flat granules such as are found on the periphery of abactinal, marginal, and sometimes actinal plates of several genera of Goniasteridae, e.g. *Iconaster*, *Astroceramus*, *Lithosoma*, *Plinthaster*, *Calliaster*.

Koehler compares *Pergamaster* with *Plinthaster* but its 2 or 3 coarse furrow spines and subambulacral tubercle are reminiscent of *Astroceramus*. It seems to me that *Lithosoma* and *Iconaster* (especially its subgenus *Glyphodiscus*¹) are also related, but more distantly perhaps than *Astroceramus* and *Plinthaster*. Pedicellariae aid in establishing relationships but these are not present in *Pergamaster*.

Pergamaster incertus (Bell)

(Plate II, figs. 1, 2)

Pentagonaster incertus Bell, 1908, p. 9.

? *Pergamaster tessellatus* Koehler, 1920, p. 238, pl. 49, figs. 5-17.

St. 1872. East of Joinville Island, Antarctic Archipelago, 63° 29.6' S, 54° 03.1' W, 247 m., 1 small specimen.

The specimen measures R 13.5 mm., r 8 mm., br at interradius 8 mm. It differs from the type of *incertus* in having the actinal plates surrounded by only a single series of granules as in the smaller specimen of *synaptorus*. If the latter species shows this variation, probably due to age, it is likely that *incertus* does also. The specimen has been identified as *incertus* because the radial abactinal plates extend to the terminal plate, and the abactinal plates and granules are less plane than in *synaptorus* and thereby resemble more nearly those of *incertus*. Superomarginals 6 or 7, furrow spines 2 or 3; the distal granule of inner subambulacral series enlarged to a clavate tubercle thicker than furrow spines and of about the same length.

Mr D. Dilwyn John had made two photographs of the type of *incertus*, of which R is 26-27 mm., and r 14 mm., and which are reproduced herewith. Bell's vague remarks in lieu of a description, though perhaps technically sufficient to establish the species, are quite valueless for purposes of identification. The photographs show that the furrow spines are generally 2 and that the subambulacral tubercle is essentially as in the small specimen listed above. The actinal interradii areas are completely covered with granules as in the type of *synaptorus*.

¹ Fisher, 1919, p. 306; *G. perierctus* Fisher, *loc. cit.* pl. 79, fig. 4; pl. 81, fig. 3; pl. 83, figs. 2, 3; pl. 93, figs. 1, 1a.

It seems likely that Koehler's *Pergamaster tessellatus* is at best only a form of *incertus*. His 3 specimens were all larger, R being 43, 40 and 35–36 mm. Koehler does not mention the prominent subambulacral tubercle which appears to be absent on the proximal plates but can be seen with a lens on the distal plates in figs. 6 and 8, pl. 49 (Koehler, 1920). In the type of *synaptorus* this tubercle is sporadic on the proximal plates but regularly occurs in the paratype. Koehler's specimens (1920, p. 238, pl. 49, figs. 5–17) were taken at 2 stations: 64° 34' S, 127° 17' E, 1700 fathoms and 64° 32' S, 97° 20' E, 110 fathoms.

TYPE LOCALITY. McMurdo Sound, south-west corner of Ross Sea, about 77° S, 96–120 fathoms.

Pergamaster synaptorus sp.nov.

(Plate II, fig. 3; Plate III, fig. 1)

DIAGNOSIS. Differing from *Pergamaster incertus* (Bell) and *P. tessellatus* Koehler in having the distal 5–7 pairs of superomarginals joined medially, excluding abactinal plates from terminal part of ray. R 45 mm., r 27 mm., br at interradius 28 mm.; paratype measures R 33 mm., r 13.5 mm., br 13.5 mm.

DESCRIPTION. The precise form and arrangement of the abactinal plates can be determined from the figures. The exposed surface of the plate is flat and is in reality a very low tabulum surrounded by a single series of unequal flat granules, flush with the surface. Koehler uses the misleading term "little plates" for the granules. The adradial row of plates extends to the middle of the fourth superomarginal of type (and to middle of third of paratype) while the radial series continues to middle of eighth superomarginal (sixth of paratype). Beyond this point 5–7 superomarginals meet in the midradial line, those of opposite side, but are usually not accurately paired. Papulae inconspicuous, occupying a broad petaloid radial area. Madreporite variable, small to large, situated at mid r.

The marginals are bare except for the peripheral series of elongate or squarish granules flush with surface. The plates of the 2 series sometimes correspond, sometimes do not. Superomarginals 13–14 (11–12 in paratype) block-like, broader than long, and forming a rounded border to ray and disk. The second plate is conspicuously larger than first, and thence they decrease very gradually in size along ray.

The inferomarginals form a more abruptly rounded margin and, from the fourth plate on, are in contact with adambulacrals (fifth in paratype).

The actinal plates of type are completely covered with coarse close-set polygonal granules, but those of paratype have only a peripheral series leaving the centre of plate bare. There are 3 chevrons of these plates to each interradian area. The series adjacent to adambulacrals extends to proximal border of fourth inferomarginal of type (one-half to one plate farther in paratype).

Adambulacral plates proximally a little broader than long and narrowing on ray proper until the two dimensions are about equal. Furrow spines 2 or 3, subequal, heavy, blunt, sometimes slightly compressed, and about as long as width of plate. Back of these

are 4 or 5 coarse granules in 2 longiseries. The aboral granule of inner series is often enlarged into a tubercle one-half or two-thirds length of furrow spine. In the paratype this tubercle is present on nearly all the plates, is thicker than furrow spines, and increases in length so that on ray proper it is as long as and much heavier than the furrow spines. In the type its occurrence is very irregular.

The combined mouth-plates are lozenge-shaped actinally, the furrow margin being about as long as the first adambulacral suture. Marginal spines 4 or 5, similar to proximal adambulacral furrow spines but a little longer and gradually lengthening to the oral angle where the 2 "teeth" are the longest spines on the body. Each plate normally has one suboral adjacent to distal marginal spine while the outer half of combined plates is covered with low coarse granules.

TYPE LOCALITY. St. 170. Off Cape Bowles, Clarence Island, 342 m., rock, 2 specimens.

REMARKS. This species differs from *P. incertus* as indicated in the diagnosis. In all the specimens of *P. tessellatus* Koehler, of which the largest has R 43 mm., the midradial series of abactinal plates reaches the terminal plate, thereby separating the distal superomarginals; while the adjacent adradials reach the ninth or tenth superomarginals, which is farther than the *radial* series reaches in *P. synaptorus*. In the much smaller type of *incertus* the adradials reach to the sixth superomarginal (11 in all) or to about one-third R from end of ray. In *P. synaptorus* the adradials extend along ray two-fifths R (or to three-fifths R from end of ray).

Genus *Cladaster* Verrill

Cladaster analogus sp.nov.

(Fig. D, 2; Plate IV, figs. 1-3)

DIAGNOSIS. Closely related to *Cladaster validus* Fisher; stellato-pentagonal with short rays, thick disk, block-like marginals and unequal, spaced granulation on surface of plates; madreporite larger than any abactinal plate; pedicellariae very broadly spatulate with flat jaws, arising from a pit on the plate but without a differentiated depression for the opened jaws; superomarginals 11; adambulacrals with 2, sometimes 3, heavy, compressed round-tipped furrow spines; one major subambulacral and a secondary smaller one on outer end of plate independent of the small marginal granules. R 57 mm., r 34 mm., br (interradius) 35-37 mm.

DESCRIPTION. The abactinal plates are fairly regularly arranged on the radial areas in series parallel to the midradial, in which the largest plates are situated about one-third R from the conspicuous subcircular central plate. Across the ray from interradius to interradius and passing the midradial series at about mid R are 13 plates. The radial plates are subcircular to subhexagonal, the others mostly subcircular. They are separated by a shallow furrow covered normally by the close-set, peripheral granules which are superficially 4-sided, round-tipped, convex, and deciduous. The exposed surface really constitutes a very low tabulum and is nearly plane. It normally carries, spaced unequal,

deciduous subspherical granules, the largest of which are slightly larger than the peripheral, the smallest (more round-tipped cylindrical to thimble-form) decidedly smaller than the peripheral. A majority of these granules have been rubbed off the plates. Here and there is a small tongs-shaped pedicellaria arising from a depression of the plate. The jaws are spatulate, constricted at middle, and about 0.5 mm. wide by 0.5 mm. high. The large flat madreporite is one-third r from centre; diameter 5 mm. Papulae very small, apparently about 6, around plates of radial area.

The marginal plates are block-like, wider than long, convex, and form a thick, rounded border. Both series regularly diminish in size distally. Superomarginals 11, the last plate of one series meeting 1 or 2 of opposite side of ray medially. The plates are bordered by squarish granules similar to the abactinal while the surface is covered with very deciduous, slightly spaced, subspherical granules which increase in size to small tubercles in centre of plate, especially toward end of ray. The inferomarginals are similarly provided with granules which are slightly more uniform in size.

A single row of actinal plates extends the length of 5 or $5\frac{1}{2}$ inferomarginals; the next row, $2\frac{1}{2}$ or 3; the third, 2; the fourth, $1\frac{1}{2}$; while the remaining 2 chevrons are in the span of the interradiial pair of plates. The actinal plates are rather ornate with 1-3 central granules; or, on inner 3 series, a central broadly spatulate pedicellaria, with jaws about twice the height and breadth of the abactinal. The peripheral granules are regularly much larger on the side toward margin and end of ray.

The adambulacral armature is essentially that of *Hippasteria*, consisting of 2, sometimes 3, heavy, compressed, round-tipped furrow spines about as long as width of plate. On centre of plate is a much heavier subcylindrical round-tipped tubercle (with a smaller adoral companion on first 4 or 5 plates). Near outer end of plate is a tapered tubercular spine about half as long, or sometimes 2, side by side. The margin of plate (except the furrow) is occupied by prismatic granules *like those of adjacent actinals*, which elongate into coarse prismatic spinelets toward furrow. I find only one subambulacral spatulate pedicellaria. Marginal oral spines 6, coarse, compressed and prismatic; suborals crowded, about 6 to an oral angle.

TYPE LOCALITY. St. WS 86. Falkland Islands, $53^{\circ} 53' 30''$ S, $60^{\circ} 34' 30''$ W, 151-147 m., shell and stones, 1 specimen.

REMARKS. This species is very closely related to *C. validus* Fisher¹ from Amukta Pass, Aleutian Islands, $52^{\circ} 06'$ N, $171^{\circ} 45'$ W, 283 fathoms, rocks, black sand, hydrocorals. The only known specimen of *validus* has R 17 mm., r 10 mm., and is probably young. It differs from *analogus* in minor details such as a definite tumid naked area on the superomarginals. Although most of the superomarginals of *analogus* have lost their granules, the scars are discernible and there appears to be nothing like a specialized area. In *analogus* the madreporite is larger than any abactinal plate; in *validus* it is distinctly smaller than the radials, although this may well be associated with immaturity. In *validus* the pedicellariae are abactinally a trifle larger (relative to size of plate) than in *analogus* and the jaws have more distinctly incurved ends. The actinal pedicellariae of

¹ Fisher, 1911, p. 222, pl. 41, figs. 1, 2.

analogus have broader jaws. Considering the difference in size of the two specimens, the adambulacral armature is remarkably alike. In *validus* the second or outer subambulacral tubercle (distinct from the marginal series of granules) is not developed, although on the margin of plate there are 1 or 2 granules larger than the immediately adjacent actinal granules. In *analogus* these outer marginal granules are subequal to the adjacent actinals.

The disparity in size of the peripheral granules of actinal plates occurs also in *validus*.

In *Cladaster rudis* Verrill¹ the only example has R 25 mm., r 12 mm., and 4 distal superomarginals in contact medially. The pedicellariae have narrower jaws of a different form to those of *validus* and *analogus*. In *rudis* there is no specialized naked area on the superomarginals, the granules being scattered. The dark spots shown in Verrill's fig. 2 (which might be interpreted as specialized areas) I was unable to observe with a strong lens. The adambulacral armature of *rudis* lacks the second subambulacral spine, there being, as in *validus*, 2 enlarged marginal granules just external to the subambulacral spine.

In *C. macrobrachius* Clark² from Cape of Good Hope (R 40 mm., r 16 mm.) the 5 distal pairs of superomarginals meet medially, and in spite of its smaller size most of the adambulacrals have 3 furrow spines, while the subambulacrals are generally in 3 longi-series of 3 spines each, the aboral of the first series and the median of the outer being really spines—the rest scarcely more than granules.

Hippasteria imperialis Goto,³ a large species from 640 m. off Misaki, Japan, is possibly a *Cladaster* but hardly a *Hippasteria*.

Genus *Hippasteria* Gray

Döderlein⁴ has shown that *Hippasteria* is not closely related to *Anthenea*, with which it was formerly associated in a special family by Perrier, but is a typical Goniasterid near to *Calliaster*, while *Anthenea* is an Oreasterid. Verrill⁵ segregated *Hippasteria* from *Anthenea* in 1899 making of it and *Cladaster* a subfamily Hippasteriinae. Döderlein could have strengthened his case by citing *Cladaster*, which is obviously a typical Goniasterid yet very closely related to *Hippasteria*. Likewise, *Hippasteria imperialis* Goto,⁶ possibly a *Cladaster* or else a new genus, bridges completely any hiatus which may have existed between *Hippasteria* and thoroughly typical Goniasteridae. It follows therefore that the subfamily Hippasteriinae is superfluous.

Hippasteria falklandica sp.nov.

(Plate III, fig. 2; Plate IV, fig. 4)

DIAGNOSIS. Resembling *Hippasteria heathi* Fisher of Alaska, but lacking the prominent abactinal and marginal spines of that species and differing in minor details of adambulacral armature and in granulation of marginal plates. Differing from *H. phrygiana* (and presumably also *H. hyadesi*) in the different form of the abactinal plates

¹ Verrill, 1899, p. 176, pl. 28, figs. 2–2c.

³ Goto, 1914, p. 338, pl. 12, figs. 178–193.

⁵ Verrill, 1899, p. 174.

² Clark, 1923, p. 268, pl. 13, figs. 1, 2.

⁴ Döderlein, 1922, p. 47.

⁶ Goto, 1914, p. 338.

and their indistinctness; in the large number of abactinal and marginal pedicellariae; in the irregularity of the marginal plates, wholly covered with granules and lacking characteristic tubercles. R 129 mm., r 43 mm., R=3r; br 52 mm. (least distorted ray).

DESCRIPTION. Perriers' description of *H. hyadesi* (Straits of Magellan, 326 m.) is limited to a short comparison of the type with *H. phrygiana*.¹ No figures were published and so far as I am aware no second specimen has been taken. Perrier states, in effect, that the only difference between *hyadesi* and *phrygiana* lies in the wider ambulacral furrow of the former. In the adambulacral armature he finds slight differences but some of these are covered by variations of *phrygiana*. I have therefore assumed that the characters of abactinal plates and marginal plates in respect to form, armature, and occurrence of pedicellariae seemed to Perrier to be almost indetical in the two species. As these features are radically different in *H. falklandica* I have considered it safe to use for comparison a specimen of *H. phrygiana* (R 105 mm.) from 75 fathoms off Martha's Vineyard, Massachusetts, which closely resembles Mortensen's figure² of a Skagerrak example.

The following account of *falklandica* is largely in the form of a comparison with *heathi* and *phrygiana*. It is hoped that the photographs may supply information on details omitted or too summarily treated.

Abactinal surface. The outlines of the plates are rather obscure and difficult to distinguish on account of the crowded, unequal granulation, except in the case of numerous oblong-elliptical primary plates. Almost the entire surface of these is occupied by a long, low, bivalved (or trivalved) pedicellaria. On the border of these plates are unequal low granules, very unequally spaced, or no granules at all. Smaller secondary and tertiary plates usually carry a central globose prominent tubercle, occupying most of the surface. Interspersed among these, as may be seen in the photograph, are 3 or 4 sizes of small tubercles and granules none of which clearly outline subcircular or irregular secondary and tertiary plates as in *phrygiana*. In *phrygiana* the subcircular primary plates generally carry a central thimble-shaped tubercle, the length of which seldom exceeds the width of plate (but greatly exceeds it in *H. spinosa* Verrill of the north Pacific). The rest of the surface is bare and periphery is bordered neatly by close-set, small granules. In *falklandica* none of the plates show a bare surface, and therefore greatly resemble *H. heathi* Fisher³ from 206 fathoms, Clarence Straits, Alaska, which I am inclined to regard as a much closer relative than is *phrygiana*. Some of the abactinal plates of *heathi*, however, carry prominent upright tubercular spines like those of *H. spinosa*.

MARGINAL PLATES. These are covered with unequal coarse granules and irregularly placed short subglobose or acorn-shaped tubercles, with often a large bivalved pedicellaria. Superomarginals 22 or 23, longer than wide except toward tip of ray where they are wider than long and where a few plates have a bare surface. They are distinctly smaller than in *phrygiana* and *heathi* and, partly due to granulation, are not sharply differentiated from the abactinals. The (larger) specimen of *phrygiana* has only 16

¹ Perrier, 1891, p. 128.

² Mortensen, 1933, pl. 11, fig. 2.

³ Fisher, 1911, p. 231, pl. 44, figs. 1, 2; pl. 58, figs. 5, 5a; pl. 60, fig. 6.

superomarginals which very gradually decrease in size toward the end of ray, whereas in *falklandica* the terminal 4 or 5 plates increase in size. The plates vary greatly in the number (1-5), size, and position of the tubercles and pedicellariae.

Except at tip of ray, the inferomarginals are distinctly larger than the superomarginals and are irregularly 4- to 6-sided. Owing to the covering of granules and tubercles they are not at all clearly marked off from the actinal plates. The usually 4 or 5 unequal tubercles are very irregularly distributed, while the valves of the large pedicellariae are sometimes subdivided into 2 or 3 to allow for a slight curvature.

The marginals are entirely different from those of *phrygiana*, in which the superomarginals carry 1 or 2 central thimble-shaped tubercles and the inferomarginals, 1-5, and only exceptionally a pedicellaria. In *H. heathi* the marginal spines (usually several to a plate) are much more prominent even than in *phrygiana*, but the proximal superomarginals and nearly all the inferomarginals carry, in addition, a bivalved pedicellaria, as in *falklandica*. Instead of the neat peripheral series of granules of *phrygiana*, *heathi* approaches *falklandica* in having stout unequal conical granules in 1 or 2 interrupted series. But most of the surface is taken up by the stout spines and pedicellariae.

ACTINAL INTERMEDIATE AREAS. Nearly all the plates are occupied by exceptionally long low bivalved pedicellariae (lower and longer than in my specimen of *phrygiana*), and are bordered by a series of very unequal, coarse, often squarish or prismatic granules. Interspersed smaller plates, especially near margin of area, carry 1 or 2 subspherical tubercles slightly smaller than the largest abactinal ones. In *heathi* these tubercles are short thick spines, shorter than the prominent marginal spines.

ADAMBULACRAL ARMATURE. Furrow spines more often 2 than 3, coarse, compressed, round-tipped. Behind these are 3 subambulacral tubercles, the inner shorter but broader than the furrow spines, round-tipped, broad side to furrow; the next is about half as long, but wide, often ovate in shape; the outer or third is usually an enlarged granule of a group which occupies the outer end of plate and extends along either transverse margin part way to inner end of plate. On the first plate (and in one series on the second and third) the subambulacral tubercles are replaced by a large bivalved pedicellaria. Orals 5 or 6, suborals 1 or 2, similar to but heavier than corresponding adambulacrals.

TYPE LOCALITY. St. WS 99. Falkland Islands, 49° 42' S, 59° 14' 30" W, 251-225 m., fine dark sand, 1 specimen.

Family GANERIIDAE Perrier

Genus *Ganeria* Gray

Ganeria Gray, *Proc. Zool. Soc. Lond.*, 1847, part 15, p. 83.

Ganeria falklandica Gray

Ganeria falklandica Gray, *Proc. Zool. Soc. Lond.*, 1847, part 15, p. 83.—Sladen, 1889, p. 383, pl. 60,

figs. 1, 2; pl. 62, figs. 6, 7.—Meissner, *Arch. Naturgesch.*, 1896, p. 94.—Koehler, 1923, p. 71.

Ganeria hahni Perrier, 1891, p. 118, pl. 11, figs. 3a, 3b.—Koehler, 1923, p. 72, pl. 9, figs. 3, 4.

Ganeria robusta Perrier, 1891, p. 119, pl. 11, figs. 1a, 1b.

Ganeria papillosa Perrier, 1891, p. 121, pl. 12, figs. 1a, 1b.

St. 55. Entrance to Port Stanley, East Falkland Island, 10–16 m., 1 specimen.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 1 forma *falklandica*, 1 forma *hahni*.

St. WS 92. Between Falkland Islands and Strait of Magellan, 51° 58' 30" S, 65° 01' W, 145–143 m., 1 specimen, intermediate between forma *falklandica* and forma *hahni*.

St. WS 776. South-east of Cape Tres Puntas, Argentina, 47° 49' 37" S, 63° 42½' W, 106–113 m., 1 specimen.

St. WS 798. Off Cape Tres Puntas, Argentina, 47° 32' S, 65° 02' W, 49–66 m., 1 specimen.

St. WS 807. East of Porto Santa Cruz, Argentina, 49° 50½' S, 65° 03' W, 125–126 m., 1 specimen.

St. WS 847A. East of Porto Santa Cruz, Argentina, 50° 15¾' S, 67° 57' W, 51–56 m., 3 specimens.

St. WS 847B. East of Porto Santa Cruz, Argentina, 50° 18¾' S, 67° 44' W, 56–84 m., 3 specimens.

St. WS 849. Falkland Plateau, 50° 56¾' S, 60° 58' W, 137 m., 1 specimen.

Ganeria robusta Perrier is apparently typical *G. falklandica*, while *G. papillosa*, founded on a single specimen, may well represent an individual variant of forma *falklandica*. *G. hahni* is distinguished particularly by its slender rays, rather than by peculiarities in number and disposition of spines, since the latter characters are repeated in certain broad rayed specimens referable to forma *falklandica*. The type of *G. hahni* is probably *sui generis* rather than the representative of a natural forma, although I have used the name in the record of specimens.

G. falklandica is decidedly variable but the amplitude seems to be less than in *Cycethra verrucosa*. Among the specimens of the latter from St. 55 is a curious variant discussed in connection with examples believed to represent Perrier's *Lebrunaster*. This specimen has the proportions of forma *hahni*, the rays being narrow. The actinal surface is clearly that of *Ganeria*. The marginal plates are small; the tabula are well spaced one from another, and carry 7 or 8 spines in the equivalent of 2 series after the manner of some variants of *Ganeria*. Some of the proximal marginals are more paxilliform and not very different from those of *Cycethra*, having very small marginals. But the abactinal skeleton is more like that of *Cycethra* than *Ganeria*. The surface is uniformly covered with spaced, small, fasciculate groups consisting of 3 or 4 cylindrical, blunt, upright spinelets. One may safely say the animal is rather more than half *Ganeria*.

TYPE LOCALITY. Falkland Islands.

DISTRIBUTION. Falkland Plateau and the region of the Strait of Magellan; shallow water to 137 m.

Genus *Cycethra* Bell

Cycethra Bell, *Proc. Zool. Soc. Lond.*, 1881, p. 96. Type *C. simplex* Bell.

Lebrunaster Perrier, 1891, p. 116. Type *L. paxillosus* Perrier.

Under *Cycethra verrucosa* will be found notes on several aberrant specimens from Sts. 55 and WS 85 which are considered to represent Perrier's *Lebrunaster*, known only by the type specimen. These specimens combine certain characters of both *Cycethra* and *Ganeria* in such an unstable manner as to suggest that they may be hybrids.

Antarctic specimens of *Cycethra verrucosa* are peculiar and probably constitute a distinct race which shows close similarity to *Perknaster densus* as well as to typical *Perknaster*, such as *P. fuscus*.

Cycethra verrucosa (Philippi)

(Fig. C, 4a-4g)

Goniodiscus verrucosus Philippi, *Arch. Naturgesch.*, 1857, p. 130.*Cycethra simplex* Bell, *Proc. Zool. Soc. Lond.*, 1881, p. 96, pl. 9, figs. 5, 6.—Perrier, 1891, pp. 122, 170 (varieties *elongata*, *media*, *asterina*, *subelectilis*, *calva*, *regularis*, *asteriscus*).—Meissner, 1896, p. 95.—Bell, 1902, p. 215.*Cycethra electilis* Sladen, 1889, p. 377, pl. 60, figs. 3, 4; pl. 62, figs. 2, 3.*Cycethra nitida* Sladen, 1889, p. 379, pl. 61, figs. 3, 4; pl. 62, figs. 10, 11.*Cycethra pinguis* Sladen, 1889, p. 380, pl. 61, figs. 1, 2; pl. 62, figs. 8, 9.*Lebrunaster paxillosus* Perrier, 1891, p. 116, pl. 9, figs. 4a-4c.*Cycethra verrucosa* Meissner, *Zool. Anz.*, 1898, p. 394.—1904, p. 14.—Ludwig, 1905, p. 53, pl. 6, figs. 2, 3.—Koehler, 1908, p. 557.—1912, p. 64.—1923, p. 60, pl. 7, figs. 5, 11, 12, 13; pl. 8, figs. 3-9.—Döderlein, 1928, p. 296 (Kerguelen).St. 51. Off Eddystone Rock, East Falkland Island, 105-115 m., fine sand, 1 *nitida*, juv.St. 55. Entrance to Port Stanley, East Falkland Island, 10-16 m., 1 *electilis*, 3 *Lebrunaster*.St. 58. Port Stanley, East Falkland Island, 1-2 m., 1 *electilis*.St. WS 83. 14 miles S, 64° W of George Island, East Falkland Island, 137-129 m., fine green sand and shell, 1 *electilis*.St. WS 84. 7½ miles S, 9° W of Sea Lion Island, East Falkland Island, 75-74 m., coarse sand, shells and stones, 2 *pinguis*, 2 *electilis*.St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 3 *electilis*, 2 *electilis-pinguis*.St. WS 86. Falkland Islands, 53° 53' 30" S, 60° 34' 30" W, 151-147 m., sand, shell, stones, 1 *electilis*.St. WS 90. 13 miles N, 83° E of Cape Virgin's Light, Argentina, 81-82 m., fine dark sand, 1 *electilis*.St. WS 93. West Falkland Island, 133-130 m., grey sand, 2 *pinguis*, 1 *electilis-pinguis*, 1 *nitida*.St. WS 211. Falkland Islands, 50° 17' S, 60° 06' W, 174 m., 1 *pinguis*.St. WS 246. Falkland Islands, 52° 25' S, 61° W, 267-208 m., coarse green sand, pebbles, 1 *pinguis*.St. WS 248. Falkland Islands, 52° 40' S, 58° 30' W, 210-242 m., green sand, pebbles, shells, 2 *pinguis*.St. WS 755. 51° 39' S, 57° 39' W, 75 m., 5 *pinguis*, juv.St. WS 756A. Falkland Islands, 50° 54' 39" S, 59° 58' W, 118-90 m., 1 *electilis*.St. WS 776. Off Cape Tres Puntas, Argentina 46° 18¼' S, 65° 02½' W, 107-99 m., 1 *nitida*.

St. WS 791. North-east of Cape Tres Puntas, Argentina, 45° 41¾' S, 62° 45' W, 96-101 m.,

1 *pinguis*.

St. WS 796. South-east of Cape Tres Puntas, Argentina, 47° 49' 37" S, 63° 42½' W, 106-113 m.,

1 *pinguis*.St. WS 797. 47° 45' 18" S, 64° 10' 30" W, 117 m., stones, 1 *pinguis*.St. WS 809. East of Santa Cruz, Argentina, 49° 28¼' S, 66° 29' W, 107-104 m., 1 *nitida*.St. WS 811B. Off R. Gallegas, Argentina, 51° 24½' S, 67° 53' W, 96-98 m., 2 *nitida*.

St. WS 836. South-east of Atlantic entrance to Strait of Magellan, 53° 05½' S, 67° 38' W, 64 m.,

1 *nitida*.St. WS 847A. Off Porto Santa Cruz, Argentina, 50° 15¾' S, 67° 57' W, 51-56 m., 1 *pinguis*,1 *nitida*.St. WS 847B. Off Porto Santa Cruz, Argentina, 56-84 m., 1 *pinguis*.St. WS 852. 44° 12' 30" S, 64° 13' W, 84 m., 4 *nitida*.

Antarctic localities

- St. 123. Off mouth of Cumberland Bay, South Georgia, 230–250 m., grey mud; 1 specimen.
St. 140. Stromness Harbour to Larsen Point, South Georgia, 122–136 m., 1 specimen.
St. 149. Mouth of Cumberland Bay, South Georgia, 200–234 m., 1 specimen.
St. 160. Near Shag Rocks, 177 m., grey mud, stones, 1 specimen.
St. 167. Off Signy Island, South Orkneys, 244–207 m., green mud, 2 specimens.
St. 170. Off Cape Bowles, Clarence Island, South Shetlands, 342 m., 5 specimens.
St. MS 68. East Cumberland Bay, South Georgia, 220–247 m., 1 specimen.
St. MS 71. East Cumberland Bay, South Georgia, 110–60 m., 6 specimens.

REMARKS ON SPECIMENS FROM FALKLAND PLATEAU. Probably no known sea star is more variable than *Cycethra verrucosa*, which is scarcely a species in the accepted sense of the term. Rather it is a complex of a considerable number of intergrading small species and formae, which may be likened to an asymmetrical net. Some of the more conspicuous nodes have received names. But other names apply to single specimens, as in the case of certain variations described by Perrier (1891). We cannot now determine whether these illustrate actual recognizable formae, or are simply “individual variations”.

An obstacle to the establishment of named formae is the difficulty of ascertaining recognition characters which hold good for different ages. Practically all signs fail in *Cycethra*. Least stable is the breadth of ray and the size of the disk, though, generally speaking, the narrower the ray the smaller the disk.

The species, or formae, so ably described and illustrated by Sladen, are recognizable in individuals with narrow, medium, and broad rays. There is a very slender-rayed forma *electilis* which may represent a valid forma distinct from *electilis*. Similarly, *nitida* occurs in a broad-rayed form, quite different from Sladen's figure. There are large specimens combining the characters of *punguis* and *nitida*.

Koehler (1923, p. 61) gives an extended discussion and his figures are a contribution. Yet little real progress will be made until one person can assemble and compare all available material with the type specimens. Koehler has illustrated a slender-rayed forma *nitida* (1923, pl. 7, figs. 5, 11) which is (to the extent of the figures) closely similar to a specimen from St. 55, having R 65, r 18 mm. (R more than 3r). The actinal surface of our specimen is clearly not that of *nitida*, but of *electilis*. The adambulacral armature is also that of *electilis*. Three other examples from this station are similar to Perrier's *Lebrunaster paxillosus* (*vide infra*).

Before any final assignment of names can be made it will be necessary to determine the type forma, namely, forma *verrucosa*; whether this includes forma *simplex* Bell; whether *simplex* includes, possibly, forma *electilis* Sladen, or any of the seven new formae described by Perrier in 1891.

In the list of localities I have assigned most of the specimens to the “nearest” of Sladen's three categories—*punguis*, *electilis*, *nitida*, using adambulacral armature, actinal plates, and abactinal plates, but not proportions which, as stated above, are apparently

not significant. The marginal plates are very variable in size and armature. In forma *electilis* (in its broadest sense) they may be small and similar in form and armature to those of *Ganeria*.

The mystery of *Lebrunaster paxillosus* Perrier appears to be solved by three specimens from St. 55. The type and only known specimen of *Lebrunaster* was collected at Santa Cruz, Argentina, where both *Cycethra* and *Ganeria* occur. Our two largest specimens have R 22 mm., r 9 mm. and have small spaced marginals, like those of *Ganeria*, which carry 2 transverse series or in some cases only 1 series of spinelets. The actinal plates carry 2 or 3 rather short spines, about the size of the marginal spines. Lines run from margin to ambulacral furrow across the actinal area. The abactinal plates are those of *Cycethra* and carry in one specimen 3–6 spinelets in a fasciculate group; but in the other specimen there are only 2 or 3 spinelets; groups well spaced. Two other specimens (St. WS 84, R 26 mm., St. WS 85, R 25 mm.) are also "*Lebrunaster*" but the small marginals are less carinate, more typically *Cycethra*, and the adambulacral armature is like that of Perrier's fig. 4c (1891, pl. 9) which of course is typical of *Cycethra*. The actinal plates carry 3 or 4 short spinelets. The abactinal surface of the specimen from St. WS 85 shows, slightly, the irregularity of the plates of the radial area characteristic of *Ganeria*. But the actinal surface of both specimens is that of *Cycethra*, whereas in the three specimens from St. 55 the actinal surface (but not abactinal) would pass for that of an aberrant *Ganeria* with short spines, especially as the marginal plates are those of *Ganeria*. It was probably the *Ganeria*-like marginal plates which led Perrier at the end of his description of *Lebrunaster paxillosus* to say "voisine de *Ganeria*".

In a fourth specimen, from St. 55 (R 39 mm.), the armature of the adambulacral and actinal plates is that of *Ganeria*. The marginal plates have well-spaced tabula bearing the equivalent of 2 transverse rows of spines (7 or 8 in all) but in a few cases the spinelets form a fasciculate group with one in the centre. The abactinal surface carries small, uniformly spaced, fasciculate groups of 4 or 5 spinelets, without any irregularity of plates on the radial region. It is therefore *Cycethra*. These curious specimens, exhibiting in different degrees the characters of *Ganeria* and *Cycethra*, may be hybrids and suggest a possible explanation of *Lebrunaster*. No typical *Ganeria falklandica* was taken at St. 55; but at St. WS 85 a small specimen of forma *falklandica* and a large one of forma *hahni* were dredged, along with *Cycethra* and that example of "*Lebrunaster*" having a slight distortion of the radial abactinal plates.

These aberrant *Cycethra* (except the specimen from St. 55 which is most *Ganeria*-like) would fall in forma *electilis*. Sladen's figures (1889, pl. 60, figs. 3, 4) of the type are not very different from Perrier's figures of *Lebrunaster*. The marginal armature is spaced.

Whatever the cause of these curious variations, I believe that the type of *Lebrunaster* is an example of them and does not represent a valid genus, or species.

REMARKS ON ANTARCTIC SPECIMENS. There are 7 specimens ranging in size R 25 mm. to R 75 mm. Thirteen young vary from R 6.5 mm. to R 14 mm. A specimen of the first group from East Cumberland Bay (St. MS 68) resembles in a general way a slender-

rayed form from Stanley Harbour, Falkland Islands (St. 55) which is similar to the specimen from the same locality figured by Koehler (1923, pl. 7, fig. 5). This South Georgia specimen has very small marginals.

The other 6 specimens are somewhat peculiar and suggest *Perknaster* (e.g. *P. densus*). The rays are more pointed than in northern forms and although narrow for the genus are characteristically inflated at the base. The marginals are very small and in 2 specimens from St. 170 they cannot be distinguished from the other plates. Yet these specimens are not separable from two taken at St. 167, South Orkneys, in which the marginals, though only slightly larger than adjacent abactinal plates and not larger than plates of radial region, can be distinguished by their contrast to the actinals.

Mr D. Dilwyn John kindly compared one of the specimens from St. 170 with the type of *Perknaster densus*. In *densus*, briefly, the abactinal and lateral surfaces are more densely covered with spine groups, the groups and spines being more closely packed. While in *densus* the actinal spines and groups are close enough together to obscure the arrangement of the plates, this is not true of the South Shetlands specimen where the groups are slightly spaced. The adambulacral armature is essentially the same in both forms. Fundamentally there are 2 furrow spinelets, slightly longer in the Discovery specimens. Mr John points out that the adambulacral spines of *densus* are less uniform than shown by Sladen's figures and description. Proximally the furrow pair form a somewhat oblique series and the distal member is more prominent into the furrow. Then in the middle part of the ray the spines are as in Sladen's figure (1889, pl. 98, fig. 12), but distally there is only *one* furrow spine. This is true of the Discovery specimens. In one specimen from St. 167, the furrow series remains slightly oblique all along the ray, with the slightly larger distal spine more advanced into furrow, until on the outer fifth of ray it, alone, stands on the margin and the other one diagonally behind it, precisely as Mr John has sketched it for *densus*. In *densus* he shows a group of four other subequal spinelets behind the second spine. In the Discovery specimens there may be a group of 3, or all 5 may form a fairly regular transverse series on the plate. In either case the arrangement is that of typical *Perknaster*.

The series of 13 young in the absence of adult specimens would probably be classified as *Perknaster* rather than *Cycethra*. The skeleton is well knit as may be expected in the young of *Perknaster*. As compared to *P. antarcticus* the abactinal spinelets are more numerous (3-8 per plate) and the skin thinner. But the spinelets are very much like those of *Perknaster* as the figures will show. Only the first few plates have two adambulacral furrow spines. Over most of the ray there is but one. Back of this spine there are three or four variously disposed, sometimes making an oblique transverse series of four with a fifth aborad to the third or fourth spine (or the interval between them). This is the typical arrangement in *Perknaster*.

Five of these young and the smallest adult were taken at St. MS 71. A spine of this adult (R 25 mm.) is figured (fig. 4a) for comparison with the abactinal spines of *P. aurorae* from St. MS 71 (figs. 3, 3a). In the latter specimen the abactinal paxillar pedicels are higher than in *Cycethra*.

I believe these young are especially valuable in indicating the close relationship between *Cycethra* and *Perknaster*.

DISTRIBUTION. Characteristic of the Falkland-Magellan fauna; north to $45^{\circ} 20' S$ on the Pacific Coast of South America, and to $40^{\circ} 40' S$ on the Atlantic coast; to $55^{\circ} S$ on the coast of 'Tierra del Fuego. Low water to 267 m.

Shag Rocks; South Georgia; South Orkneys; South Shetlands; south to Marguerite Bay, $67^{\circ} 43' S$ (Koehler, 1912).

Döderlein has recorded a very young specimen from Observation Bay, Kerguelen, near the type locality of *Perknaster densus*.

Genus *Perknaster* Sladen

Perknaster Sladen, 1889, p. 550. Type *P. fuscus* Sladen.

Cribraster Perrier, *Comptes Rendus*, CVI, no. 11, 1888, p. 675 (*nomen nudum*).—1891, p. 104. Type *C. sladeni* Perrier.

Cryaster Koehler, 1906, p. 24. Type *C. antarcticus* Koehler.

Cribellopsis Koehler, 1917, p. 36. Type *C. rallieri* Koehler.

The sea stars of this characteristic Antarctic and sub-Antarctic group are closely allied to *Cycethra* despite the decidedly peculiar and specialized structure of fully grown specimens. With increasing age the body wall thickens, while in varying degree the abactinal skeleton degenerates. In extreme cases the plates and even spinelets disappear. The glandular skin proper is thick, pulpy, and thrown into a myriad of tiny folds and pustules (at least in alcoholic specimens). Immersed in this maze of wrinkles and papillae are numerous small papulae and the small paxillae. In alcoholic specimens the latter are often difficult to distinguish, since their sacculate investment closely resembles the skin pustules and may not rise above the general level.

In 1906 Koehler described the first of the three species upon which he founded the genus *Cryaster* and the family Cryasteridae. In subsequent monographs he further elaborated *Cryaster antarcticus* and described *C. charcoti* and *C. aurorae*, as well as *Perknaster aurantiacus*. Examination of an authentic specimen of *Perknaster fuscus* Sladen, type of the genus, clearly demonstrates that all of Koehler's species of *Cryaster* are typical *Perknaster*, which obviously has priority. It will be necessary to examine the detailed structure of *P. aurantiacus* to determine whether it is distinct from *P. sladeni* (Perrier).

In the Discovery collection is a fairly representative example of the latter species which Perrier described as *Cribraster sladeni*, from a single specimen taken near the Falkland Islands. It is obviously of the same genus as *fuscus* and *antarcticus*, from which it differs *inter alia* in having tall, slender paxillae. It penetrates to high latitudes and is found along with *antarcticus* in the Palmer Archipelago. It cannot therefore be regarded simply as a northern outpost race of *antarcticus*.

Perknaster contains the following nominal species in order of naming:

fuscus Sladen 1889.
densus Sladen 1889.
sladeni (Perrier) 1891.
antarcticus (Koehler) 1906.

charcoti (Koehler) 1912.
aurantiacus Koehler 1912.
aurorae (Koehler) 1920.
georgianus nov.

Cryaster brachyactis (Clark, 1923, p. 293, pl. 11, figs. 1, 2) was dredged in Algoa Bay, South Africa, in 26 and 57 fathoms. It is very different from *Perknaster*. It has shorter and distally broader rays; a definite series of *large inferomarginal plates*, some of which bear a conspicuous spine (shown in Clark's figure); remnants of large abactinal and superomarginal plates which are not tabulate or paxilliform; large actinal plates, and very wide adambulacral plates. The skeleton, other than the ambulacral and adambulacral systems is undergoing degeneration. The body wall is thick and leathery. The species apparently represents a new genus of the Asteropidae (*vide infra*).

In order to differentiate accurately the several nominal forms of *Perknaster* it has been necessary to compare the structure of the spinelets, especially the abactinal, as well as the pedicel of the abactinal plates which carries the spinelets. Whether the small differences are as important as implied in the notes under the different forms only future experience will determine. It has seemed desirable to carry out an analysis of the most tangible or demonstrable details and leave to the future the decision whether we are dealing with a wide-ranging species, having numerous geographical races (each possibly with recognizable formae) or with several species, similarly subdivided.

The difference between *fuscus*, with its low pedicels and broadly clavate spinelets, and *sladeni*, with high pedicels and slender spinelets, seems obvious enough, although superficially the specimens are very similar. The characteristic crowded podia of *aurorae* seems to constitute a fundamental character, especially in conjunction with a spine structure definitely distinguishable from that of *fuscus* and *sladeni*.

It will not be surprising if *P. charcoti* is found to intergrade with *P. fuscus*. It must be recalled that the material of *fuscus* is still meagre and that the species probably reaches a size equivalent to the type of *charcoti*.

Koehler (1917, p. 36) has described *Cribellopsis* based upon *C. rallieri* from Kerguelen (low tide or very shallow water). The figures (pl. 5, figs. 6-10) suggest at once a species allied to *Perknaster charcoti*. The actinal interradiial areas are crossed from inferomarginal to adambulacral plates by lines or narrow grooves, and each file of plates, between two lines, corresponds to an adambulacral plate. The creases are doubtless ciliated grooves. These occur in *P. charcoti*. Koehler says: "Les papules que j'ai signalées sur la face dorsale se continuent également sur la face ventrale où elles restent très nombreuses, mais elles n'empiètent pas sur les lignes de séparation des rangées transversales de granules." This is an extraordinary state of affairs: the papulae do not encroach upon the areas of separation between the transverse rows of granules. That is, they are absent from the interval between the lines of plates, where they would be expected to occur. Papulae are difficult to distinguish in some specimens and it is possible that Koehler mistook pustules of skin, which often resemble papulae, for these organs. The matter needs confirmation by examination of the coelomic surface of the actinal interradiial areas for pores. Of course no *Perknaster* has actinal papulae.

I desire in this connection to render grateful acknowledgments to Mr D. Dilwyn John for having made comparisons of Discovery specimens with the types of *Perknaster fuscus* and *P. densus*, and later for the loan of a cotype of *P. fuscus* for examination.

A study of the actual specimen, it need not be emphasized, provided the only means of attacking a most baffling genus of a family noted for its taxonomic puzzles.

NOTE ON *CRYASTER BRACHYACTIS*¹ CLARK. This species is known from 2 specimens taken in 26 and 57 fathoms, Algoa Bay, South Africa. Dr H. L. Clark has kindly loaned me the paratype.

It is not a *Perknaster* for it has fairly large phanerozonid inferomarginal plates imbedded in the leathery body wall. These may bear, on the lateral face, a considerable group of small spinelets and also sometimes a conspicuous flattened spine, several of which are shown in the figure of the type.

Another peculiarity is the great width of the adambulacral plates as compared to those of *Perknaster*. The proximal plates commonly have 2 furrow spines in longiseries (in one case, 3) and immediately behind these a *larger* subambulacral. The outer two-thirds of plate is covered by skin only. Near the end of ray the spines form a transverse series of 2 or 3 or, rarely, 4; or sometimes only the furrow spine is present. When there is 1 furrow spine its base is broad and occupies all the furrow margin of plate.

Clark states that the "actinal intermediate areas are large, without calcareous plates, spinules, or papulae". In the paratype there are well-marked large actinal plates in irregular chevrons. A series adjacent to adambulacrals extends a little over half length of inferomarginal series, the last plate being subequal to and opposite the sixth inferomarginal. The remaining actinal interradiial triangle is crossed by 3 to 5 irregular arcs of plates, decreasing in size toward the margin and more and more separated as the margin is approached. There are a few scattered small skin-covered spinelets which disintegrate when treated with weak sodium hypochlorite.

The abactinal plates have disappeared except for about a dozen at the tip of ray. These are similar to the actinals, roundish or ovoid, some in contact, some isolated. Also at the tip are a few remnants of the series of large superomarginals. They are covered with very small, mostly degenerated, spinelets and their sacculi, which, after the distal superomarginals are recognized, can be traced to the base of ray. Over most of the ray the superomarginals have disappeared completely.

The numerous, small, slender, tapered or clavate-acute, abactinal spinelets disintegrate when treated with sodium hypochlorite although they show up plainly in a dried specimen.

The madreporite is conspicuous, 3 mm. in diameter, and contiguous to its adcentral border is an equally large primary interradiial plate.

This species, if its skeleton was complete, would have large roundish or slightly lobed abactinal plates, perhaps connected by a few secondaries; large phanerozonid superomarginals and inferomarginals; large actinal plates in chevrons or arcs, and broad but short adambulacrals.

This is not *Perknaster* and probably Mortensen (1933, p. 249) is correct in assigning *Cryaster brachyactis* and the nearly related "*Culcita*" *veneris* to the Asteropidae. I might add: in the vicinity of *Tylaster*. Since *Cryaster* is strictly synonymous with *Perknaster* it is not available for *brachyactis* which may therefore serve as the type of:

¹ *Cryaster brachyactis* H. L. Clark, 1923, p. 293, pl. 11, figs. 1, 2.—Mortensen, 1933, p. 249, pl. 12, fig. 14.

*Spoladaster*¹ gen.nov. (Asteropidae)

CHARACTERS. Those of the type species.

If I understand correctly Mortensen's remarks concerning *Culcita veneris* Perrier, of St Paul, this would probably belong also in *Spoladaster*. Its actinal interradiar areas are covered with fine spines which may occur, also, sporadically on *brachyactis*.

Perknaster fuscus Sladen

(Fig. A, 1-1*d*, 2-2*g*, 4; Plate V, fig. 1; Plate VI, fig. 1)

Perknaster fuscus Sladen, 1889, p. 551, pl. 62, fig. 1, pl. 97, figs. 3, 4.

A specimen collected by the Challenger at St. 149D, off Royal Sound, Kerguelen, was forwarded by the authorities of the British Museum, Natural History. It carries the Register Number 90.5.7.870 and measures R 34-35 mm., r 13 mm. It is therefore slightly smaller than the type specimen which was taken at the same station and which measures R 45 mm., r 14 mm. The example under observation may reasonably be considered typical of the species, a fact verified by Mr D. Dilwyn John.

Considering the small size of Sladen's figures of the whole animal and the nature of the subject, the artist was surprisingly successful. The small sacculate spinelets form a coarse nap the exact texture of which is impossible to depict by a small scale line drawing.

In Sladen's fig. 3, pl. 97, the spinelets appear to be rather more closely crowded than in the smaller paratype; but the detailed figure of the abactinal spinelets (pl. 62, fig. 1) gives an excellent idea of these structures when covered by their heavy sheath of skin. The actual spinelets are of course completely obscured by membrane.

The abactinal spinelets are in groups of 3 or 4 on the larger plates, with only 1 or 2 on smaller secondary plates. The fully developed spinelets (fig. A, 1, 1*a*) are 0.54 or 0.55 mm. long, and the distal half is built up of thin, serrate laminae radiating from the central axial portion in a rather characteristic manner. This gives the spinelets a clavate contour, and when skin-covered they have as a consequence a coarser appearance than in typical *antarcticus* of higher latitudes. The pedicel is distinctly low, as in *antarcticus*, measuring 0.18-0.22 mm. (including thickness of plate), in sharp contrast to *sladeni* in which a comparable pedicel is 0.54 mm. high. In *antarcticus*, also, the spinelet has a different form, lacking the prominent radiating laminae.

After one has compared a series of different forms of *Perknaster*, the inferomarginal plates of *fuscus* seem fairly conspicuous. They are on the actinal face and form a definite border to the actinal intermediate area and may be readily traced along the ray, where, on the outer two-thirds they are adjacent to the adambulacral plates. They carry 5-8 spinelets which do not have so numerous nor such well-developed radiating flanges as the normal abactinals (fig. A, 1*c*). The form is rather like that of abactinal spinelets from near tip of ray (fig. 1*d*).

An actinal spinelet from near mouth-plates (fig. 1*b*) measures 0.65 mm. in length and lacks the radiating flanges of the abactinal spinelets. The plates adjacent to adambula-

¹ Σπολάς, -άδος, a leathern garment.

cials usually have 2 spinelets; the others 3, 2, or 1, with a scattering having 4 or 5, rarely 6 or 7. In this specimen the membrane of the abactinal plates and spinelets is decidedly inflated, perhaps unnaturally so. Fine, rather deep meandering grooves traverse the actinal area from between the inferomarginal plates to the ambulacral furrow, passing between the adambulacrals.

Sladen's small figure gives a misleading idea of the uniformity of the adambulacral armature. The pair of much smaller spinelets which he mentions as occurring on the outer part of the plate really belongs to the first series of actinal plates. They disappear as soon as the inferomarginals come directly in contact with the adambulacral plates. The simplest armature is a transverse series of 3, the furrow spinelet robust, 1.7 mm. long, strongly compressed distally, often truncate, more heavily sheathed at base than at tip. The second and third are decreasingly smaller (e.g. 1.4 and 0.85 mm.) and are rather similar to actinal spines (see figs. 2*d*–2*f* enlarged only $\times 40$). When there are 4 adambulacral spines the fourth usually stands with the third in a longiseries along outer margin of plate or on the aboral margin opposite the interval between the second and third spines. Rather rarely there are 5 spines: an oblique transverse series of 3 and aboral to the outer 2 (the subambulacrals) 2 other similar subambulacrals. It may be stated here that the adambulacral armature of this species conforms absolutely to that of Koehler's *Cryaster*, even to the spatulate furrow spine.

Each mouth-plate has 3 or 4 marginal spines, the innermost the largest, and 3 or 4 smaller suborals closely crowded on the small plates. The marginal spines are generally compressed, but are sometimes subclavate.

The ambulacral furrows are narrow and the tube-feet are not in the least crowded as they are in *Perknaster aurorae*.

The gonads are subspherical, about 3 mm. in diameter. The gonoduct passes upward for a short distance and opens on the dorsal surface near ambitus. It should be recalled that the inferomarginals are actinal in position so that the gonopore is at least a third the distance from inferomarginals to centre of disk.

The inner surface of the abactinal body wall is a muscular sheet as in typical *Cryaster*, but the abactinal plates are rather larger than in comparable specimens of *antarcticus*.

I strongly suspect that *Cribrellopsis rallieri* Koehler, which was collected at Kerguelen, at low tide or in very shallow water, is a close relative of *Perknaster fuscus* despite the reported presence of actinal papulae. Only a comparison of specimens can settle the question.

TYPE LOCALITY. Kerguelen Island (off Royal Sound), 25 fathoms, volcanic mud.

DISTRIBUTION. Typical race known only from region of Kerguelen and Heard Islands, 25–75 fathoms.

Perknaster fuscus antarcticus (Koehler)

(Fig. B, 1–1*a*; Plate VI, fig. 2)

Cryaster antarcticus Koehler, 1906, p. 24, pl. 1, fig. 1; pl. 2, fig. 10.—1911, p. 28, pl. 4, figs. 1, 2.—1912, p. 30, pl. 3, figs. 6, 7.—1920, p. 126, pl. 27, figs. 4, 7, 8–10; pl. 29, fig. 1; pl. 30, figs. 1, 6; pl. 75, fig. 2.

St. 181. Schollaert Channel, Palmer Archipelago, 160–335 m., mud; 2 specimens.

Since the type of *antarcticus* was taken in the same region, these specimens may reasonably be regarded as typical for the size, which is close to that of the specimen of *fuscus*. They measure as follows: R 37 mm., r 12 mm.; R 35 mm., r 10 mm. In general appearance they are very similar to *fuscus* but the groups of spinelets are smaller and more closely placed (hence more numerous), while the spinelets themselves are decidedly more delicate. They measure about 0.5 mm. in length while the pedicel of the abactinal plates is 0.22–0.25 mm. high—about the same as in *fuscus*. The spinelets are slightly clavate, the terminal half being thorny but, as the figure shows, there are no radiating laminae (Fig. B, 1).

These two specimens lack differentiated inferomarginal plates. It is questionable whether much reliance can be placed on this character. The actinal spinelets are less robust than in *fuscus* and the membrane is thinner but the number of spinelets is the same.

The adambulacral spines have very nearly the same arrangement as in *fuscus* but are slenderer. The furrow spine, especially, is less robust; and instead of being chisel-shaped, it gradually tapers to a rather slender extremity. However, Koehler's figure of a large specimen of *antarcticus* from the Palmer Archipelago (1912, pl. 3, fig. 6) indicates very prominent, heavy, furrow spines, as also does his figure (1920, pl. 27, fig. 8) of a medium-sized example from Adélie Land (R 46 mm.). In this, the furrow spine is strongly spatulate. The smaller furrow spines of the Discovery specimens are probably individual variations, unless there exist definite formae with heavier and slenderer spinelets. The gonads are well developed.

Four of the specimens described and figured by Koehler (1920) were taken along the Antarctic coast between 92° E and 166° E, while a fifth (1911) came from Ross Island in the south-western corner of Ross Sea, a region far removed from the type locality, the Antarctic Archipelago. These specimens may ultimately prove to be closer to typical *fuscus* than those from the type locality.

As Koehler has shown, fully grown examples of *antarcticus* undergo a considerable loss of the dorsal skeleton, while the muscular layer of the body wall thickens. Comparison of such specimens with the small type of *fuscus* would be misleading. It is probable that large examples of typical *fuscus* exist in Kerguelen waters, since this region is well within the Antarctic zone. When these are dredged we shall know whether a corresponding reduction of skeleton takes place with advancing age.

TYPE LOCALITY. Probably Palmer Archipelago, near Port Lockroy.

DISTRIBUTION. Probably circumpolar. Records between 92° E and 166° E, 65° S to 77° 32' S (Ross Island). In the American Quadrant, along the Antarctic Archipelago. Bathymetric range, 11–335 m.

Perknaster densus Sladen

(Fig. A, 3–3f; Plate VIII, figs. 1–2)

Perknaster densus Sladen, 1889, p. 552, pl. 97, figs. 1, 2; pl. 98, figs. 11, 12. Off Cumberland Bay, Kerguelen, 127 fathoms.

St. 1563. Off Marion Island, 46° 48.4' S, 37° 49.2' E, 101–106 m., 1 specimen.

DESCRIPTION. The specimen measures R 55 mm., r 15 mm., br 17–18 mm. The disk is slightly smaller, the interbranchial arcs less angular and the rays narrower than in the drawing of the type. The compactness of the abactinal spinulation and spacing of paxillae can best be appreciated from the enlarged photograph. Small abactinal plates are scattered liberally among the larger; the former carry 1–5 spinelets, the latter 8–12, with intergrades in the size and number of spinelets. This abactinal plating passes without obvious change into that of the rounded sides of ray, and thence to actinal surface where the spinelets are slightly longer and, interradially, the plates are arranged in series from the furrow nearly to ambitus. These actinal plates or paxillae also form 4 longitudinal series adjacent to adambulacrals at base of ray, becoming less distinct and reduced to about 2 series distally. The proximal plates of innermost actinal series carry 9 or 10 spinelets about as long as the outermost subambulacrals, and they gradually decrease in length *pari passu* with the latter all along the ray. On the outer third of ray the plates of the adjacent longiseries (the inferomarginals) are larger, bearing 15–20 spinelets, and at very tip of ray touch the adambulacrals. Adorad to middle of R the inconspicuous inferomarginals, following the contour of the widening ray as in other *Perknasters*, reach the interradius on the actinal face a short distance from the actual margin. The plates become separated by the interpolation of secondary plates. One can recognize the limits of the technical abactinal surface by the change from a wrinkled, pustulated skin between the bases of paxillae to the relatively smoother (but still wrinkled) skin of the actinal area; and also by the limitation of the small papulae to the area circumscribed by the abactinal plates. Along the interradiial line between mouth-plates and inferomarginals there are 10–12 actinal plates decreasing in size toward the margin.

The madreporite is 3 by 4 mm. and situated in middle of r; surrounding it are 5 or 6 large paxillae, the largest with 19 spinelets.

The tabulum of the major abactinal plates is distinctly higher (0.45–0.5 mm.) than in *fuscus* (0.18–0.22 mm.) and is about the same as in a comparable specimen of *charcoti*. The spinelets greatly resemble those of small specimens of *charcoti* but appear to be slightly shorter (0.45–0.48 mm.). The longer actinal spinelets measure 0.58–0.7 mm., and the sharp thornlets extend further toward base (Fig. A, 3–3c). The spine sheaths are about as pronounced as in *fuscus*. The abactinal spinelets especially have a paxilli-form appearance. Certain isolated spinelets or small groups, lower than the major paxillae, may easily be mistaken for papulae.

The adambulacral armature consists of 2 prominent spatulate furrow spines about 2 mm. long, the aboral the longer, placed slightly obliquely, edge to furrow. When spines are upright the oblique furrow margin appears sometimes to carry 3 spines. Subambulacrals usually 6, varying to 5 or 7, typically in 3 pairs parallel to furrow spines, each pair successively shorter, the outermost being subequal to the adjacent actinals. Near end of ray there are 7–9 spines to a plate (sporadically 10–12). The distal of the 2 furrow spines usually stands more prominently into the furrow and is more spatulate than its adoral companion.

Mr D. Dilwyn John very kindly examined the type specimen and made *camera lucida* drawings of the armature of 4 adambulacral plates distributed along the ray from the fourth to thirty-eighth. These drawings as well as his accompanying notes indicate that the figures of the type are not quite correct. In the type, the furrow spines are compressed, perhaps less so than in the Marion Island specimen; the distal spine is more prominent into the furrow and is also slightly stronger and longer than the other, and grows progressively more so from the base of ray toward tip. The furrow spines are followed by 3 pairs of spines (varying 5-7), essentially as in the Discovery specimen. This total of 8 spines, varying 7 or 9, holds all along the ray of the type, at least as far as the thirty-eighth plate. At this point in the Discovery specimen, there are 8-10 spinelets, apparently longer than in the type. But the increasing prominence of one of the furrow spines is characteristic. In this specimen there are 75 adambulacral plates and the thirty-eighth is at about middle of ray measured on side. It is beyond the sixtieth plate that the spinelets increase, sporadically, to 10 or 12; the distal 4 or 5 plates have 5 or 6 spinelets, there being obviously one furrow spinelet; the other is squeezed behind it, as in the type.

The mouth-plates each have 4 heavy spatulate marginal spines, increasing in length toward the oral angle, and 7 or 8 suborals graduated in size as are the subambulacrals.

Ambulacral furrows narrow; tube-feet strictly biserial with large sucking disks.

REMARKS. In general appearance this species resembles *fuscus* and *charcoti*, but differs from both in the greater number of adambulacral spines. The Discovery specimen differs from the type in minor details which may represent normal variation of the species, of which only two examples are known.

Perknaster sladeni (Perrier)

(Fig. B, 3-3c, 4-4c; Plate VII, fig. 1)

Cybraster sladeni Perrier, 1891, p. 104, pl. 11, figs. 2a, 2b.—Koehler, 1912, p. 39, pl. 2, fig. 12; pl. 6, fig. 6.

St. 182. Schollaert Channel, Palmer Archipelago, 278-500 m., 1 specimen.

St. 474. One mile west of Shag Rocks, South Georgia, 199 m., 1 specimen.

In general appearance this form is closely similar to the *fuscus-antarcticus-georgianus* series but has the highest paxillae, smallest disk, and smallest actinal interradiial areas. The elongation of the pedicels of the abactinal plates which differentiates *georgianus* from *fuscus* and *antarcticus* is carried still further. The abactinal and actinal spinelets are longer than in any *Perknaster* of comparable size, are slender, terete, only slightly clavate and have the fewest thornlets at the distal end.

The more typical specimen (Fig. B, 3-3c) from St. 474 measures R 50 mm., r 14 mm., R=3.5 r; br 16 mm. The compact ovary has short lobes full of eggs measuring 1 mm. in diameter (11 November 1930).

The disk is high, the rays well arched, almost circular in section, and there is no obvious lateral margin, although with care the marginal plates can be recognized by

their slightly larger groups of spinelets, low on the side of the ray. The abactinal aspect resembles Koehler's figure of *Cribraster sladeni* (1912, pl. 6, fig. 6) except that the madreporite is smaller, a difference of no great importance since there is variation in the size of the madreporite in *georgianus* and *aurorae*. The furrow is narrow and the podia strictly biserial.

The body wall is reinforced by a tough muscular lining. Imbedded in the wall are small, spaced independent ossicles, irregularly oblong, triangular or lozenge-shape—the bases of the paxillae. They are narrower than the interspaces, and the papulae are fairly large, not numerous, irregularly distributed and confined to the abactinal surface. Each plate develops a subcylindrical pedicel or tabulum 0.48–0.55 mm. high, the convex top of which carries 2–6 slender spinelets 0.6–0.7 mm. long. The tabulum is higher than in *georgianus*. The spinelets are slender-clavate rather than capitate, and the terminal third is armed with short thorns, shorter, less spiculate, and much less numerous than in *aurorae* of comparable size. What I interpret as the proximal inferomarginal plates carry about 9 spinelets.

The small actinal areas have longer spinelets (0.8–0.9 mm.) essentially like the abactinal in form. These plates usually carry 3 or 4 spinelets in a close group and the groups are rather crowded together.

All the spines are heavily sheathed and look like tapered pointed papillae, between which the rugose skin can be seen, especially on actinal surface. Only when dry do the spines themselves become visible and take their proper shape. The sheathed spinelet is two or three times the diameter at base of the spinelet proper, whence the appearance of conical papillae.

The adambulacral armature is typically "cryasteroid"—either an oblique series of 3, decreasing in size outward from the heavy spatulate furrow spinelet (on aboral side of plate), or else a triangular group of 3 spines, the outer having moved aborally. Sometimes the outer spine is duplicated by a fourth, the two forming a longiseries. The furrow spine is frequently scoop-shaped, and the second spine may also be compressed, or spatulate. There are 4 heavy marginal mouth spines, also compressed, and about 2 suborals.

There is a prominent interbrachial septum, broader above than below, which does not extend across the actinal interradiial area but leaves a wide passage (filled with gonads). It is heavily fortified with ossicles hidden by very tough tissue. The coarse-lobed ovaries open interradially on side of ray above marginal plates. The ampullae are bilobed as in typical "*Cryaster*".

Koehler's photographs are much better than Perrier's. I have already alluded to Koehler's figure of the abactinal aspect. The ventral surface (Koehler, 1912, pl. 2, fig. 12) is in poor condition but the figure shows the coarse flattened, furrow spines. It is to be regretted that Koehler, a master of detailed description, did not give at least some figures of spinelets.

The Shag Rocks specimen is probably not typical since the type came from a faunally different area, the Falkland Plateau.

St. 182 (Fig. B, 4-4c). This specimen is heavily parasitized by an organism forming a large cyst at base of ray opening by a small actinal aperture. The largest cyst measures 15 by 10 by 10 mm. There are at least 6 of these parasites, yet the gonads are well developed. Experience has shown that sea stars parasitized by *Dengrogaster* may suffer an abnormal reduction of skeleton, yet this individual appears to be normal except for distortion caused by the cysts.

R 53 mm., r 16 mm., br about 18 mm. Since this specimen was dredged in the same general locality as the two small examples of *antarcticus* it would be rather natural to refer it to that form. But the paxillae are entirely different, having the elongate pedicels and slender longer spinelets of *sladeni*. The pedicels are commonly 0.45-0.5 mm. high, while the spinelets are 0.6-0.7 long. They are even less robust than those of the Shag Rocks specimen. This is true also of the unmodified actinal spinelets, the differences being best appreciated by a comparison of figures. A considerable number of actinal plates (as in the Shag Rocks specimen) have actinal pedicellariae composed of 2 or 3 modified spinelets bent toward one another (fig. 4c).

The inferomarginal plates are not clearly differentiated; nevertheless, the limits of the actinal intermediate areas can be traced from the fact that the abactinal paxillae are in contact whereas the actinal are slightly spaced. The former carry 2-6 spinelets which appear paxilliform on account of the sacculus. Very little skin is visible between the paxillae. The madreporite is small—2 mm. in diameter.

The adambulacral spinelets are tapered, pointed and provided each with a pulpy investment. The furrow spinelets are therefore not flattened and spatulate as is rather characteristic of the Shag Rocks specimen.

The ambulacral furrow is narrow and the podia strictly biserial.

Koehler¹ has described *Perknaster aurantiacus* from the vicinity of Adelaide Island and Alexander I Island, 92-254 m. Subsequently (1923) he recorded the same species from Shag Rocks and South Georgia (Cumberland Bay), 75-160 m. The type measured R 25 mm., r 6 mm. It is barely possible that the northern examples belong to *P. sladeni*. But the type does not have longish spinelets. Koehler states: "On n'aperçoit qu'un recouvrement de petits piquants serrés, très courts, cylindriques, très légèrement renflés à l'extrémité, qui prend la forme d'une petite tête arrondie, et pas beaucoup plus longs que hauts; ce sont plutôt des granules allongées que des piquants. On ne reconnaît aucun groupement parmi ces piquants, que restent parfaitement isolés les uns des autres, très rapprochés mais non contigus." He says further that the actinal spinelets are also short. These observations having been made from a dried specimen are doubly significant since desiccation emphasizes the pedicels and slender spinelets of *sladeni* and *georgianus*. By no stretch of the imagination can the spinelets of these forms be considered "elongated granules".

The relationship of *sladeni* and *georgianus* is a puzzle. The pedicel of the abactinal paxillae of *georgianus* is about midway between that of *sladeni* and *antarcticus*, yet *sladeni* probably occurs at South Georgia in nearly the same depth as *georgianus*. The

¹ Koehler, 1912, p. 36, pl. 3, fig. 9; pl. 4, fig. 1; 1923, p. 73.

spinelets of *georgianus* are neither those of *antarcticus* nor *sladeni* but nearer to the latter as are the small actinal interradial areas.

TYPE LOCALITY. Falkland Islands.

DISTRIBUTION. Falkland Islands, Shag Rocks, Palmer Archipelago; 199–500 m.

Perknaster sladeni georgianus subsp. nov.

(Fig. B, 2–2*b*; Plate V, fig. 2; Plate VI, fig. 3)

DIAGNOSIS. Differing from typical *antarcticus* in having an obviously higher tabulum to abactinal plates, slenderer abactinal spinelets which are less swollen at tip and have less prominent thornlets; actinal paxillae higher and usually more closely placed. Type, R 31–35 mm., r 10.5 mm., br 12 mm. R=31.

DESCRIPTION. Although the 3 specimens are small (R 33 mm. to R 35 mm.) they are sexually mature. The race is in some respects intermediate between *sladeni* and *antarcticus*. It is not close to *fuscus* since the pedicels of the paxillae are decidedly higher (0.4 mm.), while the abactinal and actinal spinelets are slenderer and differently armed.

The abactinal paxillae are also higher than in *antarcticus* owing to the higher tabulum which with plate measures 0.4 mm., while the spinelets measure 0.48–0.54 mm. In *antarcticus* the tabulum measures 0.23–0.27 mm. high and the spinelets 0.45–0.5 mm. When the spinelets are upright on the tabulum, the paxillae of *georgianus* are 0.88–0.94 mm. high (including the somewhat thinner abactinal integument) while those of *antarcticus* are 0.68–0.77 (including a somewhat thicker skin which further shortens the apparent height of the paxillae). These differences seem small but are very apparent when specimens are compared under low magnification. As will be noted from the figures, the abactinal spinelets of *georgianus* are slenderer and not at all capitate as are those of *antarcticus*. In this respect they stand nearer to the spinelets of *sladeni*.

The inferomarginal plates do not form a conspicuous actinal interradial arc as in *aurorae*. The plates can be distinguished from the actinals only by their slightly more numerous spinelets—5–7 in the interradial region, while the actinal plates adjacent carry 2 or 3. The actinal interradial areas are about as small as those of *sladeni*, and smaller than is apparent from the size of disk, since the interradial width of area is only about three-fourths minor radius. The inferomarginals are actinal in position, one-fourth r from ambitus. A few of the plates near furrow have their 2–4 slender spinelets slightly bent and co-ordinated into a pedicellaria, especially in specimens from St. 42.

In *sladeni*, from St. 474, the adambulacral furrow spinelet and often the second spinelet are compressed, while in *georgianus* they are subterete, rather slender, tapered, with occasionally a slight compression of the tip of the furrow spinelet (St. 42). Otherwise the adambulacral armature is fundamentally as in *sladeni* and *fuscus*. There are 3 spines in an oblique transverse series, the furrow spine being on the aboral side of plate. But the outer, smallest spinelet sometimes has an aboral companion, making 4 in all. This fourth spine sometimes stands aborad to the second spine of series. The first adambulacral

may have 2 spines on furrow margin and 2 on the actinal surface of plate, or only 1 furrow spine and 1 subambulacral.

The mouth-plates have 4 or 5 marginal spines and 2 or 3 shorter suborals in a parallel series. They are subterete, slightly tapered, bluntly pointed.

In one specimen from St. 42 the madreporite measures 1.5 by 2 mm.; in the other it is 2.5 by 2.4 mm.; in that from St. 140 it measures 1.5 by 2 mm. This character is therefore unstable, and the disparity between the madreporites of the type of *sladeni* and of the Shag Rocks specimen is probably without taxonomic significance.

Although a specimen measures only R 33 mm., the ovaries are well developed and contain eggs 0.75 mm. in diameter.

Just how to treat this recognizable form is something of a problem. It is as distinct from *antarcticus* as is *fuscus*. Its high paxillae, slender spinelets, and small actinal inter-radial areas appear to relate it to *sladeni*. But the specimen of *sladeni* from the Palmer Archipelago complicates the matter since it indicates a range which would reasonably include that of *georgianus*. No specimen typical of *sladeni* has been taken at South Georgia, proper, and it is possible that *georgianus* does have some geographical or ecological significance. Only more material can answer the question.

TYPE LOCALITY. St. 42. Off mouth of Cumberland Bay, South Georgia, 120–204 m., 2 specimens.

SPECIMENS EXAMINED. In addition to two from St. 42, a paratype from St. 140, Stromness Harbour to Larsen Point, South Georgia, 122–136 m.

Perknaster charcoti (Koehler)

(Fig. B, 5–5*e*; Plate VII, fig. 3)

Cryaster charcoti Koehler, 1912, p. 33, pl. 2, figs. 8, 9; pl. 3, fig. 8.—1920, p. 132.

St. 39. East Cumberland Bay, South Georgia, 179–235 m., grey mud, 1 specimen (A).

St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud, stones, 1 specimen (B).

St. 149. Mouth of East Cumberland Bay, South Georgia, 200–234 m., 1 specimen (C).

The three specimens measure as follows:

Specimen A, St. 39, R 90 mm., r 34 mm., br 34–39 mm. (specimen pressed flat); specimen B, St. 148, R 51 mm., r 16 mm., br 19 mm.; specimen C, St. 149, R 102 mm., r 40 mm., br 43–47 mm.

Specimen B is the only one which is at all comparable to the example of *fuscus*, from Kerguelen, in which R=34 mm. Although B is larger and a light yellowish brown in colour, while *fuscus* is dark brown, the two are very similar, especially in the features of the actinal surface. The adambulacral spinelets as a rule form a transverse series of 3, precisely as indicated by Sladen in his figure of the type of *fuscus* (1889, pl. 97, fig. 4). The furrow spine is strongly compressed, heavily sheathed, and its base occupies almost the entire length of the plate. The second spine is also compressed, but is about three-fourths as long as the furrow spine, while the third is tapered and about two-thirds the length of the second. Just external to the third is a pair of actinal spines which Sladen

mistook for adambulacrals. As a variation, there may be a fourth small spinelet in line with the series or else placed aborad to the third spinelet. The whole armature forms a cheval-de-frise along the furrow margin very conspicuously higher and heavier than the small actinal spinelets which are in well-spaced groups of 2, less often 3. The interradi al area is crossed by the characteristic deep wrinkles or dermal grooves.

The inferomarginal groups of 5 or 6 spinelets clearly mark the border of the actinal area and are actinal in position, at the interradius about $\frac{1}{5}r$ from the ambitus. Above or beyond them the abactinal spinelets are sharply differentiated from the actinals by their heavier investment of skin and the much closer juxtaposition of the paxillae, which carry 1, 2, or 3-5 spinelets. These are normally hidden by a sheath common to the whole paxilla. That is, the group of spinelets is enclosed in a wrinkled bag of pulpy tissue (while in *fuscus* each spinelet is separately visible). The skin between the crowded sacculate groups is raised into lower deeply wrinkled welts among which it is difficult to differentiate the papulae. These are, however, rather evenly scattered all over the abactinal area, being readily seen from the inner surface of the abactinal wall. The latter is much thicker than in *fuscus*, but some of the difference must be discounted owing to the greater size of specimen B. This body wall further thickens in the larger specimens. In C it reminds one of the body wall of a leathery holothurian.

Coming to the details of the spinelets of specimen B (Fig. B, 5*a*), the resemblance is rather close to *aurorae*, but the spicules or thornlets build a smaller head to the spinelet, as a rule. Fig. 5*a* (left) is a young spine, indicating the terminal origin of thornlets. The spinelets are the same length as in equal-sized specimens of *aurorae* (0.53-0.63 mm.). The pedicel, however, is a little higher (0.36-0.45 mm.), and distinctly higher than in *fuscus*. The actinal spinelets are 0.7-0.75 mm. long and the armature of slender thornlets is no more extensive than in the shorter abactinal spinelets. It is therefore much less than in the actinal spinelets of *aurorae*.

In large examples (figs. 5, 5*e*) the thornlets either are absorbed or are broken in the case of the abactinal spinelets since none could be found having the characteristic structure of fig. 5*a*. In specimen C the spinelets (fig. 5, enlarged $\frac{1}{2}$ scale of fig. 5*a*) are around 0.7-0.75 mm. long and appear to represent only about $\frac{2}{3}$ of fig. 3. The actinal spines of large specimens (fig. 5*e*) are also very different. There is no longer any trace of the delicate spicules of specimen C. The terminal third is covered with short asperities, somewhat like rose thorns in shape. Such a transformation is not found in comparable large specimens of *aurorae*.

Koehler has fully described the adult with excellent photographic figures. Certain emendations are necessary since he had only the type from Petermann Island. He emphasizes the peculiarity of the large, spatulate, innermost adambulacr al spine with its heavy sheath of tissue which forms a membranous expansion along either edge of the spatula, thereby increasing its apparent width. This spatula is not so wide in the Discovery specimens as in the type, and is often not wide at all, but is narrow and gouge-shaped, with a thickened, slightly bifid truncate end, the extremity being one-third to one-half the width of the end of Koehler's figure (pl. 3, fig. 8). This extremely broad

spine is therefore not characteristic; nor is the number of adambulacral spines 2, as might be inferred from Koehler's description. The prevalent number is 3, in a slightly oblique transverse series, as in specimen B; or a small fourth spine may stand aborad to the median or to the outermost spine.

Koehler states (1920, p. 132) that on the actinal interrarial areas of *charcoti* the spinelets are more developed (développé) than in *antarcticus* and are sometimes coordinated into small groups; that they have therefore undergone less degeneration than in *antarcticus*. The individual spines are probably larger in *charcoti* but Koehler's comparative figure of *antarcticus* (1912, pl. 3, fig. 1) shows more numerous actinal spinelets than in *charcoti*, and even a slight grouping is indicated. In small specimens of *antarcticus* the spinelets are regularly disposed in small, slightly spaced groups of 2 or 3. In each of the 3 specimens of *charcoti* the small groups of 2 or 3 spinelets are very definite, well spaced. In specimens A and C those groups near the furrow function as primitive spiniform pedicellariae. In such groups the spinelets are usually slightly curved toward each other.

In large specimens the abactinal paxillae are well spaced and in specimen A are submerged in the myriad folds of the highly rugose glandular skin; in specimen C the spinelets extend slightly above this skin as in Koehler's figure (pl. 2, fig. 9). On the lateral part of the *abactinal* area, deeper transverse channels resolve themselves from the maze of intricate folds to continue actinally between the marginal plates and across the actinal area, disappearing between the combs of adambulacral spines.

Although the tube-feet are large, they are not crowded as in *aurorae* and preserve an approximate biserial arrangement.

Specimen B, having R 51 mm., has well-developed subspherical ovaries.

Colour note, specimen C. Pale yellow with red interrarial streaks on interradii and a few vertical red streaks on sides of arms.

TYPE LOCALITY. Petermann Island, Graham Land coast.

DISTRIBUTION. South Georgia and Petermann Island, low tide to 235 m.

Perknaster aurorae (Koehler)

(Fig. C, 1-1c, 2-2a, 3-3d; Plate 7, fig. 2)

Cryaster aurorae Koehler, 1920, p. 120, pl. 27, figs. 1-3, 5, 6; pl. 28, figs. 1-11; pl. 29, figs. 2-6; pl. 30, figs. 2-5; pl. 75, fig. 1.—1923, p. 73.

St. 366. Four cables south of Cook Island, South Sandwich Islands, 77-152 m., 1 specimen.

St. 370. Two miles north-east of Bristol Island, South Sandwich Islands, 18-80 m., 2 specimens.

St. 371. One mile east of Montagu Island, South Sandwich Islands, 99-161 m., 9 specimens.

St. MS 71. East Cumberland Bay, South Georgia, 110-60 m., 1 specimen (see note below).

Perknaster aurorae differs from all other forms in having broader ambulacral furrows, in which the more numerous, larger podia are crowded out of the strictly biserial arrangement. Even in specimens as small as the example of *P. fuscus* this crowding is conspicuous and contrasts very sharply with the condition in *fuscus* where the furrow is so narrow that the furrow spinelets of opposite margins interlock. In every specimen of

aurorae the podia force apart the margins of the furrow. In large examples at the middle of furrow 3, or rarely 4, podia can be counted in a transverse series. In the example of *fuscus* there are 84 podia to a ray while in a slightly smaller example of *aurorae* there are 108.

The dorsal aspect of the 2 species is practically the same. Both are covered with close-set blunt papillae. But the structure of the spinelets is different, those of *aurorae* being almost brush-like from a multitude of sharp thornlets which do not so obviously form the margins of radiating lateral flanges. In contrast to *sladeni* and *georgianus* the pedicel of the paxillae is low, as in *fuscus* and *antarcticus*.

In *aurorae* both series of marginal plates are clearly discernible. In large specimens they become separated in the interbrachial arc by several series of smaller intermarginals similar to the lateral abactinals. The marginals carry 8 or 9 spinules about as large as adjacent actinal spinules.

The largest of the Discovery specimens, from St. 370, measures R 112 mm., r 44 mm., br 48 mm. The smallest specimen, from St. 371, measures R 34 mm., r 12 mm., br 14 mm. The others are scattered between these limits.

The structure of the abactinal spinelets described and figured by Koehler (1920, pl. 75, fig. 1) is highly characteristic. Each spinelet is clavate. The enlarged tip bristles with numerous slender thorns buttressed to their neighbours by trabeculae which increase in number as the thorns or spicules lengthen. Separating the trabeculae are holes of varying size (Figs. C, 2, 2a). When the spinelets begin to degenerate as the animal reaches fully adult size, the trabeculae are absorbed first, leaving a row of serrations along the adjacent borders of neighbouring spicules (fig. 2a). In some large specimens the spinelets are not so well developed as shown by fig. 2 (St. 366) but may have the shorter spicules of fig. 1 (St. 371) which represents a smaller specimen (R 40–50 mm.). Koehler (1920, pl. 75, fig. 1) gives photomicrographs of spinelets but the figures have suffered by the routing of the background. Koehler's fig. 1c is nearest to the spinelets of the Discovery specimens. The pedicels of the abactinal paxillae are usually a trifle higher than those of typical *antarcticus* (figs. 1b, 3d).

The adambulacral furrow spine, and even the second spine, is usually strongly compressed or spatulate as is clearly shown by Koehler's figures.

A specimen with R 43 mm. already has the gonads well developed.

NOTE ON SPECIMEN FROM ST. MS 71 (Fig. C, 3–3d). This specimen from South Georgia is not at all typical but it is nearer to *aurorae* than any other species. It measures R 48 mm., r 16 mm., R=3r, br 18 mm. The gonads are well developed. The spinelets have rather fewer and coarser thornlets than has typical *aurorae* while the pedicel of the paxillae is higher than in typical southern specimens (compare figs. 1b and 3d). The spinulation of the abactinal surface passes into that of the actinal without a conspicuous break, although small inferomarginals with 5–8 spinelets can be recognized in contrast to the actinals which usually carry 3, but adjacent to furrow, 4 or 5. Most of these groups of actinal spinelets are modified into pedicellariae, the 2–5 spinelets being bent toward a common centre (fig. 3b). Although such spiniform pedicellariae are

rather characteristic of *charcoti* and *sladeni* they are not of typical *aurorae* and *antarcticus*. But the tube-feet of this specimen are crowded in the manner of *aurorae*, in sharp contrast to the condition in *sladeni*, which the specimen superficially resembles. Finally, the furrow spinelets are terete and not spatulate.

One might naturally regard this specimen as representing a race of *aurorae* at the northern limit of its distribution. Koehler (1923, p. 73), however, states that his example of *aurorae* (R 40 mm., r 19 mm.) from Shag Rocks is absolutely typical and conforms to a specimen of equal size taken at the type locality. He notes no difference between two small specimens, one from Graham Land and one from Cumberland Bay, South Georgia.

At this same station, MS 71, were taken one small adult (R 25 mm.) and 5 young of a *Cycethra* with slender rays and R ranging from 6.5 mm. to 12 mm. In the absence of adult *Cycethra* from South Georgia, I believe these young would be mistaken for young *Perknaster*. The resemblance is close.

TYPE LOCALITY. Davis Sea, 65° 42' S, 92° 10' E, 60 fathoms.

DISTRIBUTION. Antarctic, probably circumpolar. Recorded by Koehler from the region between 92° and 141° E (64° 32'–66° 32' S), 25–151 fathoms; Graham Land, 150 m.; South Georgia 252–310 m.; Shag Rocks, 160 m. Extreme bathymetric range, 18–310 m.

Family ASTERINIDAE Gray

Genus *Patiriella* Verrill

Patiriella fimbriata (Perrier)

Asterina fimbriata Perrier, 1875, p. 307.—1891, p. 111, pl. 12, figs. 5, 5*b*.—Koehler, 1923, p. 55, pl. 9, figs. 2, 5–8. Literature.

Patiriella fimbriata Verrill, *Amer. J. Sci.* xxxv, 1913, p. 484.—Fisher, 1931, p. 5, pl. 5, figs. 1, 2.

St. WS 81. 8 miles north-west of North Island, West Falkland Island, 81–82 m., sand, 1 specimen.

St. WS 84. 7½ miles south-west of Sea Lion Island, East Falkland Island, 75–74 m., coarse sand, shells, stones, 1 specimen.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 11 specimens.

St. WS 221. 48° 23' S, 65° 10' W, 76–91 m., 1 specimen.

St. WS 750. 52° 12' S, 67° 19' W, 95 m., 2 specimens.

St. WS 755. 51° 39' S, 57° 39' W, 77 m., 4 specimens. Ringdove Inlet, 1 specimen.

The specimens vary in size between R 6 mm. (St. WS 84) and 16 mm. (St. WS 750); two from St. WS 85 have R 15 mm.

Although this species is rather characteristic of the Falkland Plateau and the Straits of Magellan, it occurs as far north as Calbuco, Chile, and is reported by Koehler from Graham Land (64° S).

Genus *Anseropoda* Nardo

Anseropoda Nardo, Oken's *Isis*, 1837, p. 716. Type *Anseropoda membranacea* = *A. placenta* (Pennant).

Anseropoda antarctica sp.nov.

(Fig. E, 1-1c; Plate X, fig. 3; Plate XII, fig. 1)

DIAGNOSIS. Rays 5. R 17 mm., r 10-11 mm., br 12-13 mm. (body distorted). Broadly stellate, the general habit that of a thin-edged *Asterina*; disk rather arched and oral region sunken; interradial areas thin but restricted in extent. Abactinal surface covered with small, uniform truncate granules, grouped so as to indicate underlying plates; actinal plates with combs of usually 3 spinelets; adambulacral furrow combs with 6-3 webbed, slender, blunt spinelets; subambulacral combs with 5-3 spinelets; marginal oral spinelets 8, basally webbed.

DESCRIPTION. The general form is more that of an *Asterina* than of a typical *Anseropoda* owing to the arched disk and concave actinal surface. The small size obviates an extensive development of broad thin actinal interradial areas.

The abactinal surface is covered with fairly uniform truncate granuliform spinelets, 0.18-0.22 mm. long, the top of which is subcircular and armed with numerous thornlets. A profile view is shown in fig. 1. The granules, by reason of slightly differentiated spacing, form groups corresponding roughly to underlying plates, most conspicuous in the interradial areas. Larger radial plates carry 12-18 granules; the smaller interradial plates 5 or 6.

The abactinal plates are thin, scale-like and strongly imbricated, with a curved external free edge. In the median radial series this edge is directed toward centre of disk. The other plates are arranged in series parallel with the radial, and also in transverse series; and the curved free edge is toward centre of disk and radial line. On the coelomic side the dorsolateral plates each have a conspicuous process which is directed toward the margin of ray and increases in length in successive plates. This process is characteristic of *Anseropoda* (fig. E, 1a, 1b).

Apulae small, "here and there" on centre of disk, and in two radial series, one on either side of carinal plates—about 12 to a series.

Madreporite 1 mm. in diameter, situated 4 mm. from centre of disk.

Supermarginal plates small, abactinal in position, the margin ray being defined by the outer end of inferomarginals, which form a border outside of the superomarginals nearly as wide as the latter. Superomarginals carry 10-12 granules and the abactinal surface of the inferomarginals about the same number, a trifle smaller in size. There is a distinct groove between the inferomarginals (or the lateral outgrowths of the imbricated plates proper).

The actinal plates are in regular oblique transverse series corresponding each to an inferomarginal (and usually to an adambulacral). The grooves, mentioned above, continue to the ambulacral furrow between the regular lines of actinal plates. A few plates near the oral angle carry a central comb of 4 or 5 short sharp thorny spinelets, but usually there are 3 in a slightly curved comb (1-3 in very small specimens, R 5 mm.). Occasionally the spinelets stand in a group, spinelets 0.3-0.37 mm. long.

Adambulacral armature: a curved furrow comb of 6 webbed slender spinelets, the laterals much shorter than the 4 central. This number diminishes to 5, 4 and 3 as end of ray is approached. The subambulacrals are on an oblique ridge of the surface at a higher level than the marginals. They are a little shorter, more pointed, and very similar to adjacent actinals. The webbed combs usually start with 5 spines and end with 3. Furrow spines: longest 0.75 mm., shortest laterals, 0.22 mm.

Mouth-plates with 8 marginal spinelets, the 16 of an angle basally webbed and decreasing in length laterally from the central pair which are the largest spines on the body. Three or four suborals border the outer half of suture; and usually two somewhat longer ones stand between these and margin.

TYPE LOCALITY. St. 170. Off Cape Bowles, Clarence Island, 342 m., 7 specimens.

REMARKS. The specimens range in size from R 4.5 mm. to R 17 mm. (type). This is probably a small species since the type does not appear to be immature.

The species does not particularly suggest, by its general appearance, an *Anseropoda*. The abactinal granules constitute an aberrant feature since *Anseropoda* typically has delicate spinelets. Although the body is thin, its proportions have not reached the bizarre stage of *A. placenta* and other typical species. The internal processes of the abactinal and actinal plates are proportionately much shorter than in *A. placenta* and the plates of the midradial region are not obviously stellate. In large species the long internal processes are an essential anatomical contrivance in connection with numerous oblique septa all along the ray. They make possible the survival of a creature which is very thin, broad and delicate. If *A. antarctica* grows to a large size these processes undoubtedly greatly lengthen.

A curious feature of *A. antarctica* is the presence of hyaline spicules or thornlets on the dorsal, coelomic, surface of the ambulacral plates. They are best developed on the first 2 ambulacrals where they are prominent and occupy nearly the whole length of the plate, especially on the narrow part between ampullae. Further on, they are confined to the lower half of plate. I find a somewhat similar development in the relatively huge six-rayed *Anseropoda insignis* Fisher of the Hawaiian Islands.

There appears to be no described species closely related to this diminutive *Anseropoda*. The abactinal granulation, alone, is distinctive.

Genus *Kampylaster* Koehler

Kampylaster Koehler, 1920, p. 136. Type *K. incurvatus* Koehler.

Kampylaster incurvatus Koehler

(Fig. D, 3-3d)

Kampylaster ganulatus Koehler, 1920, p. 8 (*nomen nudum*).

Kampylaster incurvatus Koehler, 1920, p. 138, pl. 36, figs. 4, 6, 7, 11; pl. 37, figs. 1, 2, 3; pl. 66, fig. 10.

St. 190. Bismarck Strait, Palmer Archipelago, 93-130 m., 3 specimens.

St. 1660. Ross Sea, 74° 46' 4" S, 178° 23' 4" E, 351 m., 6 specimens.

Three of the specimens from St. 1660 are perhaps full grown, being the same size as Koehler's type—namely, R 15 mm., r 9–10 mm. The rays are bent strongly ventralward. Two specimens are carrying numerous young in the concavity adjacent to mouth (27 January 1936). Two other examples from this station having R about 10 mm. are strongly folded, while another is simply convex. The three small examples from St. 190 (R 7 mm.) are not folded ventralwards; the disk is simply convex, and in one case the ray tips are curved upward. Except when brooding young the animal probably is spread out in normal sea star fashion as Mortensen found to be the case with living examples of *Stegnaster inflatus* (Hutton). When preserved this species usually is strongly convex (Mortensen, 1925, p. 304, pl. 13, fig. 11).

A few notes need to be added to Koehler's account. He does not mention the papulae. These are difficult to see from the outside, being small and largely obscured by the granules. From the coelomic side of the dorsal surface they may be observed to occupy a radial petaloid area extending from centre of disk two-thirds the distance to end of ray. In this area there are about 16 papulae widely and unequally spaced. Koehler has described the thin overlapping plates, which lack the internal marginally directed process or lobe characteristic of the thin abactinal plates of *Anseropoda*. The abactinal granules, of which figures are given, are characteristically expanded at the base, the whole structure resembling an elaborate holothurian "table". The slightly convex summit is uniformly beset with very numerous sharp thorns. The subcircular base of each spinelet is in contact with its neighbours and is, of course, immersed in the "dermal" layer of the skin. The effect of these "tables" is to form a calcareous layer over the plates proper. The spinelets in alcoholic specimens, on account of their membranous covering, appear to be simply convex granules.

The gonads have short thick lobes, and are attached to the *dorsal* wall a short distance from the margin of interbrachium. In the case of one of the specimens carrying young the oviduct could be traced to the margin but the pore could not be located.

There is a very short stout calcareous interbrachial pillar proceeding upward from each mouth angle to the abactinal wall, the point of contact being less than $\frac{1}{2}$ r from centre. The space between pillar and margin is devoid of a membranous septum.

There are two brooding females. One of these has 26 young in a cavity involving the proximal 5 or 6 adambulacral plates of each ray. These young are 4 mm. in diameter and have about the same proportions as the adult, but the inferomarginal plates, relatively more prominent than in the adult, carry 2 or 3 outstanding spinelets the series of which forms a conspicuous fringe on the ambitus. As the animal grows and new spinelets are added to the plate these original spinelets increase in thickness faster than in length. In a specimen having R 6 mm. this marginal fringe of spinelets longer than the others has disappeared. But in *Mirastrella biradialis* just the opposite has taken place. The marginal fringe is accentuated as the animal grows. In these young there are no actinal plates. There are 7 pairs of tube-feet. The first 4 or 5 adambulacral plates carry a prominent inner spinelet and a small companion external and adoral to it; the next 1 or 2 plates have only the inner spinelet. Each mouth-plate has 2 or 3 marginal

spines. The abactinal granules are uniformly distributed and no bare furrows proceeding inwards from the interval between marginal plates are present, as in *M. biradialis*.

Figures of the spinelets of these young (figs. 3*b*, 3*c*) are of significance for comparison with those of the adult.

Koehler, by comparing *Kampylaster* with *Tremaster* Verrill (Fisher, 1911, p. 254), implies a certain similarity between the two genera which is rather far-fetched. *Tremaster* is peculiar in having 5 interradial perforations similar to those of "key-hole" sand dollars (e.g. *Mellita*). *Stegnaster* Sladen seems to be a much nearer relative and one which also has a habit of folding up when killed in alcohol (Mortensen, 1925, p. 303, pl. 13, fig. 11).

TYPE LOCALITY. Off Adélie Land, 66° 32' S, 141° 39' E, 151 fathoms.

DISTRIBUTION. Probably circumpolar: 97° 20' E–141° 39' E; Ross Sea; Palmer Archipelago; bathymetric range 93–351 m.

Mirastrella gen.nov.

DIAGNOSIS. Similar to *Kampylaster* but differing in having a double series of equivalent abactinal radial plates, tabulate inferomarginal plates, and specialized abactinal interradial grooves. Type *M. biradialis*.

Although there is much similarity in general appearance between *Mirastrella* and *Kampylaster*, the latter does not have the very unusual double row of carinal or radial plates. The plates of its normal single series are separated by encroachment of the adradials of either side which imbricate and force the radial plates apart. As the animal grows, irregularity of plates often obscures the radial series.

The young of *K. incurvatus*, recovered from the brood chamber, much more nearly resemble *Mirastrella* than do the adults. In these young the inferomarginals (4 to a ray) constitute a "phanerozoniate" border but there is no specialized tabulum. On the ventrolateral margin of plates are 2 or 3 prominent spinelets which stand out laterally and form an ambital fringe. Above these on the dorsal surface of plate are 3–5 smaller spinelets a trifle larger than the superomarginals and abactinals. As mentioned under *incurvatus* the young "grow up to" the ventrolateral spinelets which are not enlarged in the adult.

Mirastrella is readily distinguishable from *K. incurvatus* by the presence of this marginal fringe of spinelets, the tabulate character of the inferomarginal plates, and by the abactinal grooves. The spinelets of *Mirastrella* lack the subcircular, perforated, basal expansion found in *Kampylaster* while the membranous investment of the body is much thinner in *Mirastrella*.

Mirastrella superficially resembles *Leilaster* A. H. Clark (1938, p. 1, pl. 1), the type of which is *Korethraster radians* Perrier from off Barbados, 56 fathoms. I have examined a specimen of *Leilaster* which appears to belong to the Ganeriidae. Its produced inferomarginals are similar to those of *Mirastrella* but the abactinal skeleton is very different. There is a normal carinal series of plates and on either side a series of subequal adradials. The adradials of the second series, however, are conspicuously enlarged and form a

border to the abactinal area. Between these 2 rows of enlarged plates are 3 series of smaller ones—that is, the carinal and 2 adradials.

The position of *Mirastrella* is not clear. The thin imbricating abactinal plates and a certain similarity to *Kampylaster* (which in turn is perhaps related to *Stegnaster*) favour the Asterinidae. The produced inferomarginals and general appearance of the actinal surface suggests the Ganeriidae.

The species is sexually mature when R measures only 5.5–6 mm.

Mirastrella biradialis sp.nov.

(Fig. D, 4–4*e*; Plate IX, fig. 1)

DIAGNOSIS. Rays 5, R 5.5–6 mm., r 3 mm., br 3.5 mm. Form broadly stellate with thick disk, convex abactinal surface, concave actinal surface, and marginal rays sharply defined by the prominent tabula of inferomarginal plates, which are bent obliquely downward and carry 2 or 3 spinelets abruptly larger than abactinal granules; a conspicuous abactinal interradi al furrow and series of oblique superomarginal grooves; granules slightly spaced, uniform; outlines of plates indicated by differentiated furrows; adambulacral spines 3 or 4 proximally, usually in oblique transverse series.

DESCRIPTION. The arched abactinal surface is covered with subequal, slightly spaced, relatively coarse granules or granuliform spinelets invested by a very thin membrane and so disposed that individual plates are indicated by channels between the groups of spinelets. Spinelets spaced about half their own diameter, the contour of the enlarged head of spinelet being round. The spinelets lack an expanded base and measure 0.1–0.15 mm. high by 0.09–0.12 mm. broad. Their precise form, for comparison with that of *K. incurvatus*, is best indicated by fig. 4*a*. The structure of these spinelets is that of a mature animal rather than of a young one. The most characteristic features of the abactinal surface are the furrows (undoubtedly richly ciliated in life) which originate in the bare interval between the prominent inferomarginals, pass obliquely upward between the broad superomarginals, and merge with the channels separating the groups of granules. The interradi al sulcus is obviously the largest and is evident after the spinelets have been removed; its inner end meets the outer border of the primary interradi al plate (Fig. D, 4*e*, *x*).

The abactinal plates consist of a small central plate surrounded by 5 primary interradials which overlap. Outside of these is an imbricating ring of plates consisting of 5 primary radials and 5 *pairs* of plates *external* to the interradials. Between the plates of each pair passes the interradi al sulcus. These are the innermost plates of the series marked *AD'* in figs. 4, 4*e*. Between the primary radial and the terminal plate are 2 longitudinal series of imbricating plates occupying the position of the usually single series of radial, or carinal, plates. On either side of this double series (which occupies the crest of ray) are 5 or 6 larger plates composing the first adradial series (*AD* 1). Between these and the superomarginals are 3 plates of a second series (*AD* 2). Abactinal plates relatively thick. There are no internal processes as in *Anseropoda*.

No madreporic body and no papulae could be found.

The superomarginals carry about 10 granules in 2 series aligned on long axis of plate. On the lateral surface of the inferomarginals is a group of 5 or 6 similar granules while the end carries a series of 3 much stouter spinelets, the median the longer. This spiniferous part of the plate is really the pedicel of a sort of coarse paxilla. Between successive tabula are the characteristic lateral furrows.

A cleaned and dried specimen shows only 3 slender actinal plates to each ray, carrying 1 or 2 small slender spinelets each. On account of the obliquely downward growth of the inferomarginal pedicels and the convexity of disk, the concavity of actinal surface is accentuated.

Adambulacral spinelets slender, subterete, around 0.35 mm. long; proximally 3 or 4, distally 2, rather heavily sheathed and connected by this sheath at base. They are usually arranged in an oblique, transverse arc, the innermost spinelet farthest from mouth. Or 2 may occupy the furrow margin, and 2 or 1 the surface of plate. At end of ray only 2 spinelets stand in a transverse series.

Mouth spinelets, 4 on furrow margin, subequal and similar to adambulacrals.

In the paratype (R 6 mm.) the subspherical ovaries are attached to a superomarginal plate and contain a few relatively large eggs. The entire ovary is only about 0.6 mm. in diameter so that the duct could not be traced in the tiny space available. It probably opens ventrally. The large eggs suggest a "paedophoric" species.

TYPE LOCALITY. St. 160. Near Shag Rocks, 177 m., grey mud, stones.

SPECIMENS EXAMINED. St. 160, 4 specimens, R 3-6 mm.

St. 170. Off Cape Bowles, Clarence Island, 342 m., 1 specimen, R 5 mm.

Family PORANIIDAE Perrier

Genus *Porania* Gray

Porania Gray, *Ann. Mag. Nat. Hist.*, vi, 1840, p. 288. Type *Porania gibbosa* = *Asterias pulvillus* O. F. Müller.

Glabraster A. H. Clark, *J. Wash. Acad. Sci.*, vi, no. 5, 1916, p. 122. Type *G. magellanica* (Studer).

Porania antarctica Smith

Porania antarctica Smith, *Ann. Mag. Nat. Hist.*, ser. 4, xvii, 1876, p. 108.—*Phil. Trans.*, Zool. Kerguelen Island, etc., CLXVIII, 1879, p. 275, pl. 17, fig. 1.—Sladen, 1889, p. 360, pl. 59, fig. 3.—Perrier, 1891, p. 107.—Ludwig, 1905, p. 51, pl. 6, fig. 1.—Koehler, pars, 1923, p. 70 (Burdwood Bank).

Porania magellanica Studer, *Monatsber. preuss. Akad. Wiss. Berlin*, July 1876, p. 459.—Sladen, 1889, p. 363, pl. 59, fig. 5.

Glabraster magellanica A. H. Clark, *J. Wash. Acad. Sci.*, vi, no. 5, 1916, p. 122.

St. WS 80. Falkland Islands, 50° 57' S, 63° 37' W, 152-156 m., fine dark sand, 1 specimen.

St. WS 84. 7½ miles south-west of Sea Lion Island, East Falkland Island, 75-74 m., coarse sand, shells, stone, 2 specimens.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shells, 4 specimens.

St. WS 93. West Falkland Islands, 51° 51' S, 61° 30' W, 133-130 m., grey sand, 1 specimen.

St. WS 245. Falkland Islands, 52° 36' S, 63° 40' W, 304-290 m., 1 specimen.

St. WS 824. Falkland Islands $52^{\circ} 29\frac{1}{4}'$ S, $58^{\circ} 27\frac{1}{4}'$ W, 146–137 m., 4 specimens.

St. WS 825. Falkland Islands, $50^{\circ} 50'$ S, $57^{\circ} 15\frac{1}{4}'$ W, 135–144 m., 1 specimen.

St. 1563. Marion Island, $48^{\circ} 48\cdot4'$ S, $37^{\circ} 49\cdot2'$ E, 101–106 m., 2 specimens (intermediate).

St. 1564. Marion Island, $46^{\circ} 36\cdot5'$ S, $38^{\circ} 02\cdot3'$ E, 108–113 m., 4 specimens.

Although it has long been customary to regard *Porania* of the Magellanic region as identical with that of Kerguelen, Crozet, and Prince Edward Islands, the case is far from being established. The only continuity of distribution may well be through the really Antarctic *glabra* which is probably the parent form of both stocks—that of the American Quadrant and that of the African Quadrant. Be that as it may, *P. antarctica* does not range as far south as the Antarctic Convergence except at Kerguelen.

The specimens from St. 1564, Marion Island, slightly north of the Antarctic Convergence, are typical *antarctica* and have longer subambulacral spines and less robust abactinal spines than specimens from the Falkland region. The two examples from St. 1563 have only a few abactinal spines in the radial areas and are intermediate with *glabra*. Three specimens from St. 1562, Marion Island, are also intermediate but nearer to *glabra* (*q.v.*).

I believe a good series of specimens from the African Quadrant north of the Antarctic Convergence would be demonstrably different from the South American form. The few specimens obtained by the 'Discovery' from Marion Island substantiate this conclusion.

The Falkland specimens vary considerably in the number of abactinal spines, some having more numerous and larger spines than Sladen's fig. 5 which represents about the minimum number for adults. Small examples have the fewest spines—sometimes only 3 or 4 along the radial line.

In *glabra* the young may have small tubercular spines but these disappear in the adult, whereas in *antarctica* the number and size increase with age.

A specimen from St. WS 80, with R 60 mm., r 32 mm., has 30–35 *stout* tubercular spines to each ray, not counting a pentagon of 11 in centre of disk. It resembles, dorsally, an arcuate pentagonal Echinasterid such as *Poraniopsis*.

Apparently the dermal spinelets of *glabra* do not occur in this race except as rudiments in young specimens.

Colour note, St. WS 245: abactinal surface brilliant deep scarlet.

TYPE LOCALITY. Kerguelen.

DISTRIBUTION. Prince Edward, Marion, Crozet Islands; Kerguelen; Falkland-Magellan Plateau, north along the Chilean coast to Calbuco ($41^{\circ} 45'$ S).

Porania antarctica glabra Sladen

Porania glaber Sladen, 1889, p. 360, pl. 59, figs. 1, 2.

Porania spiculata Sladen, 1889, p. 362, pl. 59, fig. 4.

Porania antarctica Studer, Die Seesterne Süd-Georgiens, *Jahrb. wiss. Anstalten zu Hamburg*, 1885, p. 160.—Ludwig, 1903, p. 22, pl. 2, figs. 18–20.—Koehler, 1906, p. 10.—1911, p. 27.—1912, p. 66.—1917, p. 42.—1920, p. 178, pl. 33, figs. 6, 7.—1923, pars, p. 74 (Graham Land, South Georgia).

Porania armata Koehler, 1917, p. 43, pl. 7, figs. 3, 4, 7, 12.—Döderlein, 1928, p. 297.

- St. 39. East Cumberland Bay, South Georgia, 179–235 m., grey mud, 2 specimens.
 St. 42. Off mouth of Cumberland Bay, South Georgia, 120–204 m., 4 specimens.
 St. 45. 2.7 miles south-east of Jason Light, South Georgia, 283–270 m., grey mud, 1 specimen.
 St. 123. Off mouth of Cumberland Bay, South Georgia, 230–250 m., grey mud, 4 specimens.
 St. 141. East Cumberland Bay, South Georgia, 17–27 m., 1 specimen.
 St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud and stones, 4 specimens.
 St. 149. Mouth of East Cumberland Bay, South Georgia, 200–234 m., mud, 1 specimen.
 St. 156. South Georgia, $53^{\circ} 51' S$, $36^{\circ} 21' 30'' W$, 200–236 m., rock, 7 specimens.
 St. 159. South Georgia, $53^{\circ} 52' 30'' S$, $36^{\circ} 08' W$, 160 m., rock, 39 specimens.
 St. 160. Near Shag Rocks, $53^{\circ} 43' 40'' S$, $40^{\circ} 57' W$, 177 m., grey mud, stones and rock, 9 specimens.
 St. 170. Off Cape Bowles, Clarence Island, $61^{\circ} 25' 30'' S$, $53^{\circ} 46' W$, 342 m., rock, 10 specimens.
 St. 175. Bransfield Strait, South Shetlands, $63^{\circ} 17' 20'' S$, $59^{\circ} 48' 15'' W$, 200 m., mud, stones, gravel, 1 specimen.
 St. 181. Schollaert Channel, Palmer Archipelago, $64^{\circ} 20' S$, $63^{\circ} 01' W$, 160–335 m., mud, 1 specimen.
 St. 187. Neumayr Channel, Palmer Archipelago, $64^{\circ} 48' 30'' S$, $63^{\circ} 31' 30'' W$, 259 m., mud, 4 specimens.
 St. 190. Bismarck Strait, Palmer Archipelago, $64^{\circ} 56' S$, $63^{\circ} 35' W$, 93–130 m., rock or stones and mud, 3 specimens.
 St. 366. 4 cables south of Cook Island, South Sandwich Islands, 77–152 m., 2 specimens.
 St. 371. 1 mile east of Montagu Island, South Sandwich Islands, 99–161 m., 1 specimen.
 St. 456. 1 mile east of Bouvet Island, 40–45 m., 9 specimens.
 St. 1562. Marion Island, $46^{\circ} 52' S$, $37^{\circ} 55' E$, 97–104 m., 3 intermediate specimens.
 St. 1652. Ross Sea, $75^{\circ} 56.2' S$, $178^{\circ} 35.5' W$, 567 m., 2 specimens.
 St. 1660. Ross Sea, $74^{\circ} 46.4' S$, $178^{\circ} 23.4' E$, 351 m., 2 specimens.
 St. 1952. Between Penguin Island and Lion's Rump, King George Island, South Shetlands, 367–383 m., 1 specimen.
 St. WS 25. Undine Harbour (North), South Georgia, 18–27 m., mud, sand, 5 specimens.
 St. WS 62. Wilson Harbour, South Georgia, 15–45 m., 2 specimens.
 St. WS 65. Undine Harbour (North), South Georgia, shore collection, 1 specimen.
 St. MS 74. East Cumberland Bay, South Georgia, 22–40 m., 1 specimen.

Of the 118 specimens, 36 have R between 30 and 65 mm. and may reasonably be regarded as adult. Nine specimens from St. 456, Bouvet Island, have a few short tubercles scattered along the radial series of plates, or restricted to the outer half of ray where they may occur also on either side of the radial series. All the others, from South Georgia, the Antarctic Archipelago, and Ross Sea, have a perfectly smooth abactinal surface, although imbedded in the skin are a variable number of delicate spinelets which are clearly visible only when the specimen is dried. These spinelets are extremely numerous in the Bouvet Island specimens, occurring on the papular areas as well as plates. They never occur on the actinal surface. They appear to be a normal character of *glabra*, although they are sometimes very small and restricted to the lateral parts of the abactinal area. In small and medium-sized alcoholic specimens in which the membrane is usually thinner than in the adult the spicules, if very numerous, are often visible under a strong hand-lens, but become conspicuous only when dry, giving the abactinal surface a finely spiculate texture.

Sladen's *Porania spiculata* therefore appears to be a normal specimen of *glabra*.

Young specimens may have a variable number of short abactinal tubercles, or rarely of veritable spines, in addition to the integumentary spinelets. Such specimens are likely also to have more prominent and numerous marginal spines and more strongly spatulate subambulacral spines. This form is represented especially well by young specimens from Sts. 159, 170, 175. Apparently these tubercles are later absorbed or remain as scattered survivals (e.g. St. 456). But the spatulate character of the subambulacral spines (with or without more numerous marginals) is found in the adult stage and is characteristic of the Bouvet Island specimens as well as of others (e.g. St. 190).

In contrast to these there are young specimens (e.g. Sts. 45, WS 25, WS 62, WS 65) in which there are no abactinal tubercles while the short marginal spines are restricted to the interradial arc, the plates of the distal half of ray being smooth. The subambulacral spines are not broadly spatulate. Between these two extremes there are intergrades, as for instance at St. 159, where the spinous variation is common.

The matter resolves itself into the fact that (as in many species) there are two extremes in spine development—"multispinous" and "paucispinous", with intergrading stages. Sladen's type of *glabra* represents the paucispinous form while Koehler's *armata* is the multispinous. To the latter the Bouvet Island specimens are referable.

The absence of marginal spines from the distal plates is not a specific character. Neither does the presence of 2 (or even 3) subambulacral spines on distal adambulacral plates constitute a differential character. Even the paucispinous typical adult of *glabra* regularly carries on the distal plates 2 subambulacral spines, the form of which varies from narrowly to broadly spatulate, round-tipped to truncate.

The Shag Rocks specimens are definitely like those of South Georgia, the adults of which are devoid of abactinal tubercles and have the very delicate integumentary spinelets chiefly on the margin of the abactinal area. As might be expected the Ross Sea specimens are typical *glabra*.

One naturally wonders why Koehler, who merged *antarctica*, *magellanica* and *glabra* under one specific designation, was not more suspicious of the qualifications of his *armata*, the general locality of which (Kerguelen) had already yielded *antarctica*, *glabra* and *spiculata*.

Apropos the uniting of *antarctica* and *glabra*, Sladen distinctly states that in a good series of *antarctica* from the Prince Edward and Crozet Islands "The spiny character is present in all stages of growth". Adults of *glabra* with abactinal tubercles occur only as sporadic variations and are in no wise characteristic. It is not obvious that Koehler ever saw a *typical* specimen of *antarctica*. The Magellanic form which he lists from Burdwood Bank (1923, p. 74) certainly is not. All other specimens listed in his various papers are variants of *glabra*.

Porania glabra appears to be the pan-Antarctic form restricted to the region south of the Antarctic Convergence and ordinarily to moderate depths. *P. antarctica* in reality is sub-Antarctic, and reaches its best development well north of the Convergence.

Colour note, St. 42, South Georgia: two adults; one is orange while the other has the

abactinal surface reticulated whitish with duller papular areas; centre of disk dull orange; 5 abactinal interradiial blotches of brilliant orange.

TYPE LOCALITY. Kerguelen Island, 30 and 127 fathoms.

DISTRIBUTION. Circumpolar, Antarctic; 15–567 m.

Family ECHINASTERIDAE Verrill

Genus *Poraniopsis* Perrier

Poraniopsis Perrier, *Comptes rendus*, cvi, 1888, p. 763 (*nomen nudum*).—1891, p. 105. Type *P. echinaster* Perrier.—Leipoldt, 1895, p. 589.—Fisher, *Zool. Anz.*, xxxv, 1910, p. 568.—*Bull. U.S. Nat. Mus.*, no. 76, 1911, p. 260.

Lahillea de Loriol, *Notes pour servir à l'étude des Échinodermes*, ser. 2, fasc. 2, 1904, p. 32. Type *L. mira* de Loriol.

Alexandraster Ludwig, *Mem. Mus. Comp. Zool.*, xxxii, 1905, p. 210. Type *A. mirus* Ludwig.

Ortmannia de Loriol, *Revue critique de paléozoologie*, Paris, x, 1906, p. 78 (proposed to replace *Lahillea*, preoccupied).—Bather, *Revue critique de paléozoologie*, Paris, x, 1906, p. 131.

Lahillia de Loriol, *Revue critique de paléozoologie*, x, 1906, p. 77.

Poraniopsis echinaster Perrier

Poraniopsis echinaster Perrier, 1891, p. 106, pl. 10, figs. 2*a*, 2*b*.—Fisher, 1911, pp. 261, 265.—Koehler, 1912, p. 211.—Clark, H. L., 1923, p. 290.

Poraniopsis echinasteroides Perrier, 1891, p. 197, pl. 10, figs. 2*a*, 2*b*.—Leipoldt, 1895, p. 589, pl. 31, fig. 6.

St. 399. 1 mile south-east of south-west point of Gough Island, 141–102 m.

The single specimen measures R 46 mm., r 23 mm., R=2r; br 23–26 mm.; longest spines as follows: abactinal, 3.5 mm.; superomarginal, 4 mm.; inferomarginal, 4 mm.; subambulacral, 4.25 mm.; furrow, 3.5 mm.; greatest diameter of madreporite, 5 mm.

The abactinal spines are in 3 longiseries; including the superomarginals which border the abactinal area there are 5 series about equidistantly spaced; spines stout, tapered, bluntly pointed and seated on an elevated boss of the usually 4-lobed primary plates. The first 2 or 3 of the 19 inferomarginals carry 1 spine; the next 8–10 plates carry 2 spines, varying to 3 on 1 or 2 plates at midray; then the last 6 or 8 have 1 or 2 spines each. On the diplacanthid and triplacanthid plates the spines form a transverse series and the lower is usually somewhat flattened.

The actinal interradiial angle is not heavily armed, there being 3–6 spines (3–3.5 mm. long) to each area. The 2 adambulacral spines (occasionally 3) are strongly flattened, spatulate, subtruncate. Although some of the furrow spines are slightly concave at the tip, the upper side is not strongly grooved as in *inflata*.

There are 4 marginal oral spines, the inner or apical spatulate, shallowly concave on upper side, the others much smaller, and narrower, decreasing rapidly in size toward the first adambulacral; 1 or 2 suboral spines, heavy, concave, like the apical spine.

The madreporite is prominent, convex, and constitutes a plate independent of the adjacent adcentral primary interradiial.

Preparation of integument of papular areas reveals numerous embryonic perforated

plates of irregular outline, measuring 0.06–0.18 mm. in diameter, with as many as three layers of trabeculae in the centre. There are no integumentary spinelets or prickles such as characterize *P. mira* (de Loriol).

In comparison with *P. inflata* Fisher this particular specimen has a more flaccid body wall with obviously weaker skeleton, much fewer actinal intermediate spines, 2 inferomarginal spines (instead of 1) over most of ray; while the strong grooving of the actinal, adambulacral and oral spines of *inflata* is only faintly suggested in the furrow spines of *echinaster*. Our specimen of *echinaster* has 1 intermarginal spine at base of 6 out of 10 intermarginal areas. There are only a few inconspicuous intermarginal spinelets on the type of *inflata* but another specimen from the same region (Monterey Bay, California) has 8–13 in 1 or 2 intermarginal series.

P. inflata has been dredged from off Oregon to San Diego, California, 26–159 fathoms (Fisher, 1911, p. 264). *P. inflata flexilis* is apparently a deeper water race (334–600 fathoms) from California and probably extends to the Gulf of Panama, 458 fathoms (Ludwig, 1905, p. 210, as *Alexandaster mirus*). *P. flexilis* has a very delicate skeleton (Fisher, 1911, p. 265, pl. 64; pl. 112, fig. 2), slender acicular spines and no deposits in the abactinal integument.

H. L. Clark has described *P. capensis* from 160 and 230 fathoms, Cape Colony. It closely resembles our specimen of *P. echinaster* which is derived from a station (Gough Island) that is nearer to South Africa than to Tierra del Fuego.

Clark (1923, p. 291) has raised the question whether his species is specifically distinct from *echinaster*. The presence of 2 inferomarginal spines on many of the plates of his second specimen (1926, p. 20) is a character of *echinaster* shared by the Gough Island specimen. His larger specimen (R 68 mm.), with 2 inferomarginal spines, has the spines in general markedly sacculate which is not the case in *echinaster*, nor in *inflata*. Obviously a definitive decision must be postponed until an adequate series of specimens is available.

It is curious that a locality so near to Cape Horn as the Gulf of San Mathias, Argentina, would yield such a distinctly different species as *P. mira* (de Loriol), 1904. In this form the abactinal spines have a flattened, often capitate, tip, and are quite short and tubercular. In addition to the spines, the surface of the body is covered by a multitude of almost microscopic thorny spinelets (de Loriol, 1904, p. 33, pl. 3, fig. 1–1 h).

The only other species which has dermal spinelets is *P. japonica* Fisher from 182 fathoms off Honshu, Japan. This differs from *P. inflata*, the geographically nearest form, in having a decidedly broader abactinal area with more numerous abactinal spines, numerous delicate thorny spinelets immersed in the thick membrane of the papular areas, more widely spaced inferomarginal spines (often 2 to a plate as in *echinaster*) and adambulacral spines without a well-marked groove. The dermal spinelets are smaller, slenderer, and less numerous than those of *P. mira*.

TYPE LOCALITY. Nassau Bay, Tierra del Fuego, 95 m.

Genus *Rhopiella*¹ nov.

DIAGNOSIS. Small Antarctic Echinasteridae superficially resembling *Poraniopsis*, but differing in having a small spine on the furrow face of the adambulacral plates, in lacking intermarginal papulae, and in having gonopores in the actinal interradiar area. Differing from *Echinaster*, *sensu stricto*, in the extensive actinal intermediate areas and in the adambulacral armature, which consists of a transverse comb of spines united by delicate membrane essentially as in *Pteraster*. Paedophoric. Type, *Rhopiella koehleri*.

REMARKS. This group includes also *Echinaster hirsutus* Koehler,² *E. pterasteroides* Koehler,³ and possibly *E. smilax* Koehler.⁴ These species have a general facies unlike that of the tropical and warm water species constituting the genera *Echinaster* and *Othilia*, a fact which evidently troubled Koehler (1920, p. 118).

In keeping with the larger disk, the interbrachial septum is rather strongly fortified with calcareous plates. The septal fold extends from the body wall inward to a concave free edge impinging on the stomach, the dorsal "attachment" reaching three-fourths the distance from margin to centre of disk (*R. koehleri*).

The skeleton of Koehler's *Echinaster smilax* is close-knit in contrast to the other species in which it is very open, while the spinelets are more simple. The terminal portion is not expanded, denticulate, and hyaline as in *R. koehleri*, *hirsuta* and *pterasteroides*. Yet in the large disk, proximally swollen rays, and structure of the adambulacral armature *smilax* seems to be nearer to *Rhopiella* than to *Echinaster*.

Rhopiella koehleri sp. nov.

(Fig. E, 2-2*d*; Plate X, figs. 1, 2)

DIAGNOSIS. Resembling *Rhopiella hirsuta* (Koehler),⁵ but with only a few large papulae scattered over the abactinal area; not more than a single papula to a skeletal mesh and numerous meshes without a papula. Whole body covered by a soft opaque skin, forming a thick sheath on spinelets, and a delicate web uniting the transverse comb of usually 5 adambulacral spinelets, R 33 mm., r 10 mm., R=3.3r; br 10-11 mm.

DESCRIPTION. The general habit and the structure of the skeleton is like that of *hirsuta*. Koehler states that the number of papulae varies, in *hirsuta* from 1 to 5 or 6, according to the dimensions of the skeletal interval. In *koehleri* there is never more than one large papula to an interval and there are numerous meshes without a papula. There are no intermarginal and no actinal papillae.

The primary plates, which are irregularly lobed, carry 1 or 2 spinelets, 1-1.2 mm. long;

¹ Derived from *Rhopia*, Gray, a synonym of *Echinaster*, *sensu stricto*.

² Koehler, 1920, p. 113, pl. 12, fig. 9; pl. 24, figs. 6-9; pl. 66, fig. 2. Type locality, 66° 32' S, 141° 39' E, 151 fathoms.

³ Koehler, 1920, p. 115, pl. 16, figs. 4, 5, 8; pl. 25, figs. 3, 4, 5; pl. 66, fig. 3. Type locality, 64° 44' S, 97° 28' E, 358 fathoms.

⁴ Koehler, 1920, p. 111, pl. 12, fig. 10; pl. 25, figs. 1, 2, 6, 7; pl. 66, fig. 1. Type locality, 66° 8' S, 94° 17' E, 120 fathoms.

⁵ Koehler, 1920, p. 113, pl. 12, fig. 9; pl. 24, figs. 6-9; pl. 66, fig. 2 (as *Echinaster hirsutus*).

while the connecting, secondary plates have 1 or 2 smaller spinelets 0.8–0.9 mm. long. These are all encased in a soft but pulpy sheath which gives them the appearance of conical papillae. Koehler described the abactinal spinelets of *hirsuta* as being cylindrical in the proximal part but flattened in the distal half (also pl. 66, fig. 2). In *koehleri* the spinelets are not at all flattened distally. They are roughly clavate in form. Each spinelet is built of rather numerous radiating irregular longitudinal laminae, coarsely denticulate as shown in Fig. E, 2*b*.

The inferomarginal plates define the ambitus and carry 2–4 spinelets (similar to abactinal) in a transverse basally webbed comb. The plates are fundamentally 4-lobed but are often irregular. The superomarginals are discernible only in a cleared preparation and then cannot be followed satisfactorily proximal to middle of ray. On the outer half of ray the superomarginals, inferomarginals and adambulacrals form 3 adjacent series. Superomarginal spines similar to abactinals.

The extensive actinal intermediate areas are characteristic of the genus. The plates are generally monacanthid, the spaced spinelets forming transverse series between adambulacral and inferomarginal combs but with some irregularities. The innermost spine of the actinal series may be joined to the outer adambulacral spine by a shallow web (Fig. E, 2*c*, AC).

The adambulacral armature is a transverse series of 3 or 4 subambulacrals and 1 furrow spinelet. Fig. 2*c* shows the armature of the sixth plate of type (adoral face) while Fig. 2*d* is drawn from an excised plate (aboral face). The innermost subambulacral spine of consecutive series is involved in an inconspicuous contracted web which runs the length of furrow margin, above the furrow spine, and is homologous with the often conspicuous membrane between the innermost subambulacral spines of *Othilia* and *Echinaster*. It is indicated in Fig. 2*c*, but disappears in dried specimens.

Mouth-plates: deep in furrow a spinelet similar to adambulacral furrow spinelet; on furrow margin 3 or 4 webbed spinelets, the web continued to first subambulacral (and less conspicuously along furrow margin). Subambulacrals, 4–8 in each angle, either webbed in 2 series or variously joined to marginals.

Madreporite very inconspicuous, situated $\frac{1}{3}$ r from centre of disk, and surrounded by a variable number of spinelets.

Gonads, with short lobes, attached interradially on a level with the inferomarginal plates, the duct opening below the inferomarginals in actinal interradiial area.

TYPE LOCALITY. St. 190, Bismarck Strait, Palmer Archipelago, 93–130 m., 1 specimen.

SPECIMENS EXAMINED. St. 181. Schollaert Channel, Palmer Archipelago, 160–335 m., mud, 1 specimen. St. 363. Off Zavodovski Island, South Sandwich Islands, 329–278 m., 8 specimens.

DISTRIBUTION. Known only from Palmer Archipelago and South Sandwich Islands, 93–335 m.

REMARKS. The specimen from St. 181 has the disk strongly arched and the bases of the rays drawn together to form a brood chamber in which, close to mouth, were a few eggs measuring 3–4 mm. in diameter.

It is probable that *Echinaster smithi* Ludwig (1903, p. 34) belongs in *Rhopiella*. It was dredged in 450 m., 71° 18' S, 88° 02' W. The papulae are numerous, 3–6 to the skeletal meshes. In the absence of figures it is not possible to determine whether the species is the same as any one of the three described by Kochler.

Genus *Henricia* Gray

Henricia Gray, *Ann. Mag. Nat. Hist.*, vi, 1840, p. 184. Type *H. oculata* Gray, i.e. *Asterias sanguinolenta* O. F. Müller.

Cribella Forbes (not *Cribrella* Agassiz, 1835), *British Starfishes*, 1841, p. 100.

Cribrella Lütken, *Vid. Medd.* for 1856, 851, p. 93.

The name *Henricia* is applied to a rather considerable number of extremely unstable entities, for convenience called species, which are similar in a general way to members of the adjacent genera *Echinaster* and *Othilia*. It differs chiefly in lacking the membrane which unites the spines of the furrow edge, in the last 2 genera, into a continuous web along the margin of furrow. Of only a few forms is there enough material for a critical study of the species problem. This task is rendered all the more difficult because, added to the paucity of suitable characters, there is an extraordinary variability, and a marked tendency to what may be termed a structural equivalence in widely separated localities. An instance of this is *Henricia sufflata*, Kermadec Islands, *Henricia aspera*, west coast of North America, and *Henricia obesa*, Falkland region. So far as there are "species" in sea stars, these three are probably perfectly distinct. Yet the extremes of variation of each form very nearly bridge the gaps of structural difference between the three. *Henricia* has large eggs, and, so far as I am aware, pelagic larvae are not known in the genus. It seems probable therefore that any environmental peculiarities would have a maximum effect on individuals, and that here, if ever, we might expect to find small species developing in the inevitably many suitable but different faunal situations available.

This similarity of species from widely separated parts of the globe probably reveals a real relationship. Such equivalent species are subdivisions therefore of a sort of super-species of wide range. The same idea is carried out in the concept of a wide-ranging species with numerous subspecies.

In the case of *Henricia*, representatives of more than one superspecies may occur in a locality or region. If 2 or 3 such distinct strains (each with its variations) are regarded as varieties of one species, confusion is piled on confusion. An instance of such a confusion is to be found in the classification of the Magellanic-Falkland *Henricias*. Here representatives of two distinct superspecies, *H. obesa* and *H. studei*, have been united with the representative of yet a third, *H. paginstecheri*. Leipoldt (1895, pp. 578, 579) tossed into this *pot pourri*, also, *H. sufflata*, *H. simplex*, and by implication the then composite *H. sanguinolenta*! If these are one species, then any attempt to classify *Henricia* of the shallow waters of the world becomes absolutely futile.

As representatives of one of these "superspecies" I would adduce *Henricia scabrior* (Michailovskij),¹ *H. aspera* Fisher, *H. obesa* Sladen, *H. sufflata* Sladen. Another is

¹ S. G. Heding, 1935, p. 31.

represented by *H. abyssalis* (Perrier),¹ *H. compacta* Sladen, *H. studeri* Perrier. *Henricia scabrior* had been submerged as a forma of *sanguinolenta* until 1935, but an equivalent species (*aspera*) in the north Pacific was described by me in 1906. There it is sometimes found in the same locality with *H. sanguinolenta*.

The point of the above remarks is the belief that *Henricia pagenstecheri*, *H. obesa*, and *H. studeri* are each a segment of 3 distinct strains of very wide distribution.

I believe the only solution possible for the *Henricia* puzzle is to reduce it to a problem of a natural faunal region; to analyse these faunas one by one; and finally to trace through a mosaic of all *Henricia* faunas available the pattern of the superspecies. This was the idea I had in mind in analysing the north Pacific fauna (Fisher, 1911, pp. 266-305; 1930, pp. 194-6). Heding (1935, pp. 16-34) has made a similar attempt for the north Atlantic region.

Henricia studeri (Perrier)

(Plate XI, fig. 1)

Cribrella studeri Perrier, 1891, p. 102, pl. 9, figs. 2a-2d.

Cribrella pagenstecheri pars, Leipoldt, 1895; Meissner, 1904; Ludwig, 1905.

St. WS 81. 8 miles north-west of North Island, West Falkland Island, 81-82 m., sand, 3 specimens.

St. WS 82. Falkland Islands, 51° 30' S, 61° 15' W, 140-144 m., 1 specimen.

St. WS 84. 7½ miles south-west of Sea Lion Island, East Falkland Island, 75-74 m., coarse sand, shell, stones, 1 specimen.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 6 specimens.

St. WS 86. Falkland Islands, 53° 53' 30" S, 60° 34' 30" W, 151-147 m., sand, shell, stones, 31 specimens.

St. WS 87. Falkland Islands, 54° 07' 30" S, 58° 16' W, 96-127 m., sand, shell, stones, 1 specimen.

St. WS 97. Falkland Plateau, 49° 30' S, 61° 58' W, 146-145 m., 1 specimen.

St. WS 246. Falkland Islands, 52° 25' S, 61° W, 267-208 m., coarse green sand and pebbles, 1 specimen.

St. WS 824. South-east of East Island, 52° 29½' S, 58° 27½' W, 146-137 m., 1 specimen.

St. WS 871. Falkland Islands, 53° 16' S, 64° 12' W, 336-341 m., 1 specimen.

St. WS 872. Falkland Islands, 53° 48' S, 64° 18½' W, 139-141 m., 1 specimen.

This species, submerged heretofore as a synonym of *pagenstecheri*, is readily separable from that form since its relationships lie in another direction. *H. studeri* is a link in a chain of species, encircling the southern hemisphere, which are the antithesis of *pagenstecheri* in being characterized by having numerous spinelets compactly placed on the plates, especially the marginal, actinal, and adambulacral. The actinal series of plates extends well beyond the middle of ray, sometimes nearly to the tip. This chain of species includes *H. abyssalis* (Perrier) Mortensen, Cape of Good Hope; *H. praestans* (Sladen) Crozet Islands; *H. compacta* (Sladen) New Zealand; *H. studeri*. Probably the multispinous deep-water species, which regularly have 2 or 3 adambulacral spinelets deep in the furrow, are also related to this *compacta-studeri* group. Such, *inter alia*, are *H. pauperrima* Fisher, Hawaiian Islands, *H. densispina* (Sladen), Philippines to Korea;

¹ Mortensen, 1933, p. 265.

H. microplax Fisher, Mindanao Sea; *H. arcystata* Fisher, Philippines; *H. polyacantha* and *H. clarki* Fisher, Pacific coast of North America.

In the absence of a series of *H. compacta* it is not possible to determine what may constitute the real differences which separate it from *studer*i, for there is no reason to expect that *compacta* is less variable than other species.

I believe we can safely conclude at this time, that *studer*i and *compacta* are "divisions" of a wide-ranging subantarctic multispinous stock (as distinguished from the *simplex-pagenstecheri* stock). So far as there are species in *Henricia* these widely separated "colonies" can conveniently be called species. But the task of putting into words exactly what characters distinguish each is vastly complicated by the wide range of parallel variations which each species reveals as soon as sufficient specimens are assembled. Perhaps we shall never agree on specific limits in *Henricia* for the simple reason that Linnaean species probably do not exist.

Where *studer*i and *obesa* range together, as at St. WS 86, a few specimens may reasonably be regarded as intergrades. They are intermediate in what are assumed to be specific characters and are intergrades in the sense that they are probably hybrids. An exactly similar situation exists in the north Pacific whenever independent stocks of *Henricia* overlap in their ranges.

*Studer*i may be distinguished from *obesa* by the smaller skeletal intervals between the abactinal primary plates and the typically more numerous and slightly larger delicate spinelets of these plates. The adambulacral plates frequently have 2 spinelets deep in furrow and 12–16 subambulacral spines, of which three commonly stand on the furrow margin. There is less interval between successive plates in *studer*i. The plates of actinal surface are more densely spined and have smaller skeletal intervals. The series of actinal plates in specimens of approximately equal size extends farther along the ray in *studer*i, sometimes to the tip, whereas in *obesa* this series adjacent to the adambulacrals usually dies out at the middle of ray. This is a useful guide character for doubtful specimens but must be used in connection with the *sum* of other diagnostic features.

The general appearance of most of the specimens from St. WS 86 is closely similar to that of *H. microplax*, 200 fathoms, Mindanao Sea (Fisher, 1919, pl. 120, figs. 3, 5; pl. 121, fig. 2).

A colour note attached to a specimen from St. WS 81 reads "Orange yellow to light red dorsally, dull yellow ventrally".

TYPE LOCALITY. South of Cape Horn, 99 m.

DISTRIBUTION. Cape Horn—Falkland plateau, 74–341 m.

Henricia obesa (Sladen)

(Plate XI, fig. 2)

Cribrella obesa Sladen, 1889, p. 544, pl. 96, figs. 3, 4; pl. 98, figs. 5, 6.

Cribrella hyadesi Perrier, 1891, p. 100, pl. 9, figs. 1a–1d.—Leipoldt, 1895, p. 578, pars.—Meissner, 1896, p. 99.

Cribrella pagenstecheri Meissner, 1904, p. 13.—Ludwig, 1905, p. 68.

Henricia obesa Fisher, 1906, p. 1091.

Henricia hyadesi Clark, H. L., 1910, p. 336, pl. 2, fig. 5.

Henricia pagenstecheri Koehler, pars, 1923, p. 60.

St. WS 81. 8 miles north-west of North Island, West Falkland Island, 81–82 m., sand, 6 specimens.

St. WS 84. $7\frac{1}{2}$ miles south-west of Sea Lion Island, East Falkland Island, 75–74 m., coarse sand, shell, stones, 8 specimens.

St. WS 85. Falkland Islands, $52^{\circ} 09' S$, $58^{\circ} 14' W$, 79 m., sand and shell, 11 specimens.

St. WS 86. Falkland Islands, $53^{\circ} 53' 30'' S$, $60^{\circ} 34' 30'' W$, 151–147 m., sand, shell, stones, 19 specimens.

St. WS 93. West Falkland Island, $51^{\circ} 51' S$, $61^{\circ} 30' W$, 133–130 m., grey sand, 3 specimens.

St. WS 108. Falkland Island, $48^{\circ} 30' 45'' S$, $63^{\circ} 33' 45'' W$, 118–120 m., fine dark sand, 1 specimen.

St. WS 109. Falkland Islands, $50^{\circ} 18' 48'' S$, $58^{\circ} 28' 30'' W$, 145 m., fine dark sand, 1 specimen.

St. WS 220. South-east of Cape Tres Puntas, $47^{\circ} 56' S$, $62^{\circ} 38' W$, 108–104 m., 1 specimen.

St. WS 243. North-east of Falkland Island, $51^{\circ} 06' S$, $64^{\circ} 30' W$, 144–141 m., coarse dark sand, 13 specimens.

St. WS 248. Falkland Island, $52^{\circ} 40' S$, $58^{\circ} 30' W$, 210–242 m., fine green sand, pebbles, shells, 4 specimens.

St. WS 576. Berkeley Sound, $51^{\circ} 35' S$, $57^{\circ} 49\frac{3}{4}' W$, 34–24 m., 1 specimen.

St. WS 776. Off Cape Tres Puntas, Argentina, 107–99 m., 2 specimens.

St. WS 782A. North Falkland Island, $50^{\circ} 29\frac{1}{4}' S$, $58^{\circ} 23\frac{3}{4}' W$, 141–146 m., 1 specimen.

St. WS 791. North-east of Cape Tres Puntas, $45^{\circ} 38' S$, $62^{\circ} 57' W$, 97–96 m., 1 specimen.

St. WS 796B. South-east of Cape Tres Puntas, $47^{\circ} 53\frac{1}{2}' S$, $63^{\circ} 32\frac{1}{2}' W$, 108–112 m., 1 specimen.

St. WS 804. North-west of West Island, Falkland Islands, 150–143 m., 1 specimen.

St. WS 807. East of Porto Santa Cruz, $49^{\circ} 50\frac{1}{2}' S$, $65^{\circ} 03' W$, 125–126 m., 1 specimen.

This species differs from *H. studeri* (Perrier) in having a rather large-meshed abactinal skeleton—a characteristic which is illustrated by Sladen's and Perrier's figures. The actinal skeleton is also more open, with larger meshes and smaller plates. In both species 3 longitudinal, regular series of plates are usually present, representing 1 actinal (contiguous with adambulacrals) and 2 marginal series. The actinal series extends to about the middle of ray, and in robust specimens of *obesa*, a second, shorter actinal series is present exterior to the first. As a matter of fact this second series is present also in slenderer rayed specimens (similar to the type of *hyadesi*) but the skeletal spaces are smaller. Similarly, 1–3 short longiseries of intermarginal plates are present at base of ray, the length of series and spacing varying with robustness of ray.

There are about 6–9 subambulacral spines, usually arranged with 1, sometimes 2, on the furrow margin (above the curved, generic, furrow spinelet), followed by 2 not very regular trans-series of 3 or 4 spines each; or the innermost spine is followed by 1 or 2 similar but slightly shorter ones, and then a group of 3–6 spinelets. There is considerable variation in arrangement but the spinelets are fewer in number than in *H. studeri*. In very small specimens occasionally plates carry a single transverse series of 5 or 6 spinelets after the manner of *pagenstecheri* (q.v.).

It hardly seems useful to divide this species into named formae such as forma *obesa* and forma *hyadesi*, on account of the large number of intermediate variations not quite typical of either. One variant (e.g. from Sts. WS 248 and 782A) does not show a clear

serial arrangement of the actinal and marginal plates, which gives the specimens a very abnormal appearance. An analogous, sporadic, variation occurs in *Henricia leviuscula* of the Pacific coast of the United States.

The largest specimen (St. WS 791) measures R 72 mm., r 16 mm., br 18–21 mm.

A specimen from St. WS 81 carries a colour note: orange red dorsally and dull yellow ventrally.

Clark (1916, p. 60) has recorded as *hyadesi* 11 specimens from Tasmania, Bass Strait, south of Gabo Island (Victoria), and Great Australian Bight, 50–200 fathoms. Dr Clark has sent me a specimen from each locality except Bass Strait. While they undoubtedly closely resemble the Magellanic species, an extensive series of *obesa* and *studer* throws a different light on the matter. The specimen from south of Gabo Island seems to me to be a slender-rayed form of *H. sufflata*, Kermadec Islands. That from 78 fathoms, east of Maria Island, Tasmania, is possibly also a form of *sufflata* (but definitely not *hyadesi*); while that from the Great Australian Bight is of the *compacta* group, with numerous adambulacral spines.

Whether or not this interpretation is correct, it is, nevertheless, evident that in the waters south of Australia there are forms closely similar to both *studer* and *obesa*, just as in the Auckland-Campbell Islands there is a form equivalent to *pagenstecheri* of South Georgia.

TYPE LOCALITY. Challenger St. 315, Port William, Falkland Islands, 12 fathoms, sand, gravel.

DISTRIBUTION. Typically a species of the Falkland Plateau and Magellan region; north on the Pacific side of Iquique, Chile (Meissner) and on the Atlantic side to north-east of Cape Tres Puntas, Argentina; 24–242 m. in the Falkland region; as deep as 245 fathoms off entrance to Smyth Channel (Challenger). It is possible that the record from Iquique, Chile, may refer to another, nearly related form. *H. australis* Barattini (1938) off Uruguay, closely resembles *obesa* and may be one of its numerous variants.

Henricia pagenstecheri (Studer)

(Plate XI, fig. 4)

Cribrella pagenstecheri Studer, 1885, p. 158, pl. 2, figs. 6a, 6b.

Henricia pagenstecheri Koehler, pars, 1923, p. 60 (Shag Rocks).

St. 6. Tristan da Cunha, 80–140 m., rock, 1 specimen.

St. 25. 19 miles north-east of Jason Light, South Georgia, 18–27 m., 2 specimens.

St. 39. East Cumberland Bay, South Georgia, 179–235 m., grey mud, 1 specimen.

St. 123. Off mouth of Cumberland Bay, South Georgia, 230–250 m., grey mud, 1 specimen.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122–136 m., green mud and stones, 4 specimens.

St. 141. East Cumberland Bay, South Georgia, 17–27 m., 1 specimen.

St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud and stones, 1 specimen.

St. 149. Mouth of East Cumberland Bay, South Georgia, 200–234 m., mud, 1 specimen.

St. 156. South Georgia, 53° 51' S, 36° 21' 30" W, 200–236 m., rock, 1 specimen.

St. 160. Near Shag Rocks, 53° 43' 30" S, 40° 57' W, 177 m., grey mud, stones, rock, 5 specimens.

St. 474. 1 mile west of Shag Rocks, 199 m., 1 specimen.

St. WS 27. South Georgia, 53° 55' S, 38° 01' W, 106–109 m., gravel, 1 specimen.

The largest specimen, St. 39, measures R 17 mm., r 5 mm., br 5 mm. Koehler (1923) records 2 specimens from Shag Rocks, 160 m., having R 30 and 36 mm. It is probable that the species never attains a size comparable to that of *obesa*. Rays slender to medium robust.

The adambulacral armature consists of a transverse series of 4 or 5 prominent subambulacral spinelets, decreasing in length from furrow outward, and in addition 1, or occasionally 2, shorter, but still prominent spinelets deep in furrow. The subambulacral spinelets are the longest on the body. The consecutive series are well spaced from one another and constitute a conspicuous cheval-de-frise all along the furrow margin. The single series of actinal plates extends to middle of ray and each carries 1 to sometimes 2 or 3 delicate spinelets, shorter than the outer subambulacrals (and much shorter than the longer furrow members of series). The marginal plates do not form very regular series. The inferomarginals carry 3-5 short spinelets in a transverse series or a group, while the superomarginals (not always recognizable) are like the abactinals and carry usually 1-3 short spinelets in irregularly spaced groups.

The papulae are dorsally 1 or sometimes 2 to each mesh of the skeleton; laterally and ventrally they are single, and extend to the adambulacral plates, adjacent to which there is a regular series for the entire length of the ray. (This series is entirely lacking in the fine specimen of *simplex* from Marion Island. In this the papulae do not cross the inferomarginal plates, *there being no true actinal papulae*.)

The tiny specimen from Tristan da Cunha has R 6 mm. and r 2 mm. It has actinal papulae and is not distinguishable from an equal sized specimen from St. 140.

Mortensen (1925, p. 304, pl. 13, figs. 1, 2) has given notes on *H. lukinsii* of the Auckland-Campbell Islands and has differentiated it from *pagenstecheri*. It is probably a valid "small species", but it is only fair to record that some of the peculiarities of *lukinsii* are not so apparent when a good series of *pagenstecheri* is examined. For instance, in the latter the spinelets of the proximal marginal plates often form transverse series with those of the adambulacral and actinal intermediate plates. The true furrow spine of *pagenstecheri* is not always directed horizontally but may be bent upward (as viewed from actinal aspect). There is sometimes (e.g. St. 25) a conspicuous actinal interradiar naked area, or slight depression, in the angle outside the oral plates, as stated by Mortensen, but this area may also be nearly or quite obliterated by small spinelets, singly or in twos (Sts. 39, 123). The rays of *lukinsii* are stouter and the disk larger than in any of my specimens of *pagenstecheri*.

In spite of these apparent discrepancies I agree with Mortensen that there is an average difference between the two forms both of which are small in size and hence most difficult to evaluate accurately.

TYPE LOCALITY. South Georgia.

DISTRIBUTION. South Georgia, Shag Rocks, Tristan da Cunha, 18-250 m.

Henricia pagenstecheri parva (Kochler)

Cribrella parva Kochler, 1912, p. 40, pl. 4, figs. 3, 8.—1920, p. 118, pl. 25, fig. 10; pl. 26, figs. 1–11; pl. 66, fig. 4.

St. 170. Off Cape Bowles, Clarence Island, South Shetland Islands, $61^{\circ} 25' 30''$ S, $53^{\circ} 46'$ W, 342 m., rock, 1 specimen.

St. 1948. North-east of Clarence Island, $60^{\circ} 49' 4'$ S, $52^{\circ} 40'$ W, 490–610 m., 1 specimen.

This race is close to *pagenstecheri* from which it differs chiefly in having slightly larger abactinal plates carrying upward of 10 small spinelets which, like those of the South Georgia species, are minutely thorny. The adambulacral spinelets are not particularly different from those of *pagenstecheri* other than being slightly more numerous. Ordinarily there are 5 or 6 subambulacral spines in a single transverse series, the 2 ranks of combs on either side of furrow forming a prominent cheval-de-frise. But on the first 2 or 3 plates there are 7 or 8 spinelets in 2 complete or incomplete series. Here and there the adambulacral armature is aligned with the actinal and inferomarginal spinelets which are in close-set groups of 3–8 and do not form regular longiseries. The small single papulae extend to the adambulacral plates.

The specimen from St. 1948 measures R 22 mm., r 6 mm., br 6.5 mm.

The example from St. 170, measuring R 18 mm., r 4.5 mm., br 5 mm., is not at all typical in respect to adambulacral armature. The plates of the proximal half of ray in addition to a prominent furrow spinelet (or occasionally 2) have 7–9 subambulacral spinelets, arranged in the equivalent of 2 transverse series as a rule, but very irregularly so. Far along ray there is often a transverse series of 3 spines and a group of 3 or 4 smaller spinelets on the outer part of plate.

Kochler (1920) reported *parva* from off Adélie Land and Queen Mary Land, 110–151 fathoms. Abactinally, these resemble *pagenstecheri* quite as much as they do *parva*.

TYPE LOCALITY. Admiralty Bay, King George Island, South Shetlands, 420 m.

DISTRIBUTION. Antarctic, circumpolar; 191–610 m.

Henricia simplex (Sladen)

(Plate XI, fig. 3)

Cribrella simplex Sladen, 1889, p. 547, pl. 97, figs. 5, 6; pl. 98, figs. 9, 10.

St. 1564. Off Marion Island, $46^{\circ} 36' 5'$ S, $38^{\circ} 02' 3'$ E, 108–113 m., 1 specimen.

The specimen measures R 36 mm., r 8 mm., br, beyond constriction, 10 mm. The photographic figure is introduced to indicate wherein this relatively large specimen varies from that illustrated by Sladen. There are usually 4 subambulacral spines in a single transverse series and these combs are aligned with the 1 or 2 actinal and 2–4 inferomarginal spinelets. The actinal plates extend about one-third length of ray measured on side. The superomarginals are not well marked except on outer third of ray; at the base of ray they are separated from the inferomarginals by a lateral wedge-shaped area of intermarginals—3 or 4 plates wide at interradius. The lowermost regular series of papulae lies just under the superomarginals on the lateral face of ray. *There are*

no papulae between the inferomarginals and actinals, nor between the latter and the adambulacrals. If the absence of actinal papulae is constant in specimens from Marion, Prince Edward, and the Crozets, then *simplex* may be readily distinguished from *pagenstecheri* in which there are actinal papulae even in specimens having R only 6 mm.

Sladen has recorded *simplex* from Tristan da Cunha where the 'Discovery' secured a tiny specimen of *pagenstecheri*. It would be an easy matter to confuse the two forms for they are not distinguishable on spine characters alone. Since Sladen describes abactinal and intermarginal papulae, but no actinal papulae, it seems almost certain that he had in hand *simplex* and not *pagenstecheri*.

DISTRIBUTION. Prince Edward Island, Marion Island, Crozet Islands, Tristan da Cunha, 50–150 fathoms.

Henricia diffidens (Koehler)

Echinaster diffidens Koehler, 1923, p. 58, pl. 8, figs. 1, 2; pl. 9, figs. 9, 10.

St. WS 840. 53° 52' S, 61° 49' W, 368–463 m., 1 specimen.

St. WS 871. 53° 16' S, 64° 12' W, 336–341 m., 3 specimens.

The largest specimen, from WS 840, measures R 17 mm., r 5.5 mm., br 6.5 mm.

The spines are somewhat longer than those of Koehler's specimens, particularly the types from Graham Land, indicating the possible existence of a different race on the Falkland Plateau.

It is not evident why Koehler placed this species in *Echinaster*, as it is of the general habit of *Henricia*, and very small specimens greatly resemble equal sized *H. pagenstecheri* but have more numerous, longer abactinal spines, fewer and less obvious actinal papulae. In the largest specimen the true actinal papulae appear at about the end of the proximal third of furrow (measured from mouth) at about the point where the actinal plates end. From this point to end of ray the spaced papulae lie between the inferomarginal and adambulacrals plates. Proximal to that point actinal papulae do not regularly occur.

H. diffidens greatly resembles two north Pacific species: *H. asthenactis* Fisher¹ and *H. longispina* Fisher.²

At St. WS 871 was taken also one specimen of *H. studeri*.

TYPE LOCALITY. Graham Land (Swedish Antarctic Expedition, St. 5) 64° 20' S, 56° 38' W, 150 m., sand and gravel.

DISTRIBUTION. Graham Land, South Georgia, Falkland Plateau, 75–463 m.

¹ Fisher, 1911, p. 297, pl. 77, fig. 1; pl. 111, figs. 4, 4a. Vicinity of Santa Barbara Island, California, to Bering Sea, 178–682 fathoms.

² Fisher, 1911, p. 299, pl. 76, figs. 1, 2; pl. 111, figs. 3, 3a. Vancouver Island to southern Alaska, 41–134 fathoms. A race of *longispina* occurs near Attu, Aleutian Islands, 135 fathoms (*H. longispina aleutica*, p. 300, pl. 77, fig. 2).

Family SOLASTERIDAE Perrier, emended

Genus *Lophaster* Verrill

Lophaster Verrill, *Amer. J. Sci. Arts*, ser. 3, xvi, 1878, p. 214. Type *Solaster furcifer* Düben & Koren. *Sarkaster* Ludwig, *Mem. Mus. Comp. Zool.*, xxxii, July, 1905, p. 185. Type *Sarkaster validus* Ludwig.

DIAGNOSIS. Five-rayed¹ Solasteridae with cruciform or lobed abactinal paxilliform plates (without intermediate connecting ossicles) forming a skeleton of quadrate or polygonal meshes; with 2 well-developed series of marginal paxillae, and with usually a single series of spaced actinal intermediate plates, with or without a paxilliform tuft of spinelets, extending far along the ray; adambulacral armature not essentially different from that of *Solaster*; an interbranchial calcareous pillar from actinal to abactinal surface, but no membranous interbranchial septum between it and interbranchial angle as in *Crossaster*.

Lophaster stellans Sladen

(Fig. E, 3, 3a)

Lophaster stellans Sladen, 1889, p. 460, pl. 71, figs. 4, 5; pl. 72, figs. 11, 12.—Ludwig, 1903, p. 27, pl. 3, figs. 23, 24 (western Antarctica, not typical).—Koehler, 1920, p. 151.

Lophaster pentactis Perrier, 1891, p. 112, pl. 9, fig. 3, 3a-3e.—See Koehler, 1920, p. 151, pl. 31, figs. 6, 7; pl. 68, fig. 3 (type).

Lophaster levinseni Perrier, 1891, p. 7 (*lapsus*).

St. WS 81. 8 miles N, 11° W of North Island, West Falkland Island, 81-82 m., sand, 3 specimens.

St. WS 83. 14 miles S, 64° W of George Island, East Falkland Island, 137-129 m., fine green sand and shell, 2 specimens.

St. WS 243. North-east of Falkland Islands, 51° 06' S, 64° 30' W, 144-141 m., coarse dark sand, 7 specimens.

St. WS 244. Falkland Islands, 52° S, 62° 40' W, 253-247 m., fine dark sand and mud, 1 specimen.

St. WS 246. Falkland Islands, 52° 25' S, 61° W, 267-208 m., coarse green sand, 2 specimens.

St. WS 799. South-east of Cape Tres Puntas, 48° 04½' S, 62° 48' 07" W, 141-137 m., 1 specimen.

St. WS 825. North-east of East Island, Falkland Islands, 50° 50' S, 57° 15¼' W, 135 m., 1 specimen.

St. WS 840. 53° 52' S, 61° 49' W, 368-463 m., 1 specimen.

St. WS 848. North-east of Atlantic Entrance to Strait of Magellan, 115-117 m., 2 specimens.

If there were any utility in recognizing 2 formae in this species, names are available. Forma *stellans*, illustrated by Sladen, has a large disk and broad rays tapering evenly to a pointed extremity. Two specimens from St. WS 83, with R 36 mm. and 30 mm., are typical. Forma *pentactis*, illustrated photographically by Koehler, has slender rays and the sides of the ray are at first subparallel and then taper gradually on the outer part. The marginal paxillae have longer pedicels. This form was taken at all the other stations except WS 799. One specimen from this station and one of those from WS 81 have the longer marginal paxillae, but the rays are intermediate between the two extremes.

¹ Exceptionally six-rayed, as a meristic variation.

Sladen's specimen from 1325 fathoms off the Chonos Archipelago merits further examination on account of the great depth. One suspects the existence of a deep water form analogous to *L. furcilliger*, Alaska to Galapagos Islands, 192–1100 fathoms.

Ludwig's figures (1903, pl. 3, fig. 23) do not represent typical abactinal spinelets of *stellans*, judging by specimens from the Falkland Plateau illustrated herewith, although they are similar to Kochler's photographs of the type of *L. pentactis* (1920, pl. 68, fig. 3).

TYPE LOCALITY. Not given. Taken by the 'Challenger' at three localities, off the coast of Chile, between $45^{\circ} 31' S$ and $50^{\circ} 56' S$, 40–1325 fathoms.

DISTRIBUTION. Falkland Plateau to $48^{\circ} S$; Strait of Magellan; coast of Chile to $45^{\circ} 31' S$, 80–267 m. (except Sladen's record of 1325 fathoms which is open to question). (Western Antarctica, e.g. $71^{\circ} 14' - 71^{\circ} 19' S$, $87^{\circ} - 89^{\circ} W$, 450 m., Ludwig; possibly a different race.)

Lophaster marionis sp. nov.

(Fig. F, 1–1 d; Plate XIII, fig. 1)

DIAGNOSIS. Similar in general form to *L. furcilliger* Fisher, having narrow rays, small disk, and long pedicelled, penicillate paxillae, the inferomarginal being especially prominent; differs in lacking a definite series of actinal plates on ray and in details of spinulation especially in the more numerous unequal spinelets of marginal paxillae. R 30 mm., r 9 mm., br 10 mm. including marginal paxillae.

DESCRIPTION. Paxillae not crowded but distinctly spaced, penicillate, with 15–20 delicate, divaricate, usually 3-pronged, glassy spinelets about 0.8 mm. long on disk; pedicel slender, about as long as spinelets. Paxillae rapidly diminishing in size on outer half of ray where the pedicels are shorter than the 3–6 or 7 spinelets. The cruciform delicate abactinal plates (base of paxillae) are arranged in chevrons pointed toward centre of disk; the first chevron has 11 plates from side to side of ray, not counting the much larger superomarginals. The number then drops to 9, 7, and on outer third of ray to 5, although some irregularity exists. The plates are also aligned parallel to the superomarginals, but lateral-most row contains more plates than superomarginal series. Papulae few, 3–5 or 6 per area on disk; 2 or 3 on proximal part of ray; 1 or 0 on outer third. Madreporite small, 0.9 mm. in diameter, situated at mid-r.

Marginal plates one above the other, 20 to a ray in each series. Superomarginal paxillae abruptly larger than dorsolaterals; spinelets on proximal paxillae 12–15, similar to abactinal but a little stouter and varying in length from 0.75 to 0.85 mm.; proximal pedicels longer than spinelets.

Inferomarginal paxillae with terminally compressed pedicels slightly longer and decidedly stouter than superomarginal; spinelets proximally about 20, those on dorsal side of tip 0.6 mm. long, increasing to 1.1 mm. on ventral. The shorter have 3 or 4 prominent prongs but are broader distally than the abactinal spinelets. The longer spinelets have 4–7 prongs (Fig. F, 1 b). The first 1 or 2 inferomarginals are smaller than the succeeding. On distal third of ray the pedicels rather rapidly shorten and are about half as long as the proximal.

Actinal intermediate plates about 8, carrying 1-4 delicate thorny spinelets, and not extending beyond third or fourth adambulacral plate, except for 1 or 2 rudimentary plates near middle of some of the rays.

Adambulacral plates very short but broad with prominent muscular intervals. Furrow comb consisting of proximally 4 or 3 (exceptionally 5) delicate, slender, long, basally webbed spines; and a transverse actinal comb of usually 4 or 3 subambulacrals of which characteristically the outer 2 (or 1) are much thornier and a little shorter than the inner 2 (the former 1.6 mm., the latter 1.8 mm., Fig. F, 1c, 1d). The spine numbers run as follows along one side of ray, the Roman numerals of each couplet being subambulacral, 4-IV; 4-IV; 3-V; 3-IV; 3-III; 3-III; 3-III. On another ray it runs 5-IV; 3-V; 4-IV; 4-IV; 4-II; 3-III; 3-IV; 3-IV; 3-III; 3-III; 3-IV; 3-IV; 3-III. On outer part of ray the 2 furrow spinelets gradually align themselves with the subambulacrals so that there is a single transverse fan of 5 or 6 spinelets to a plate.

Marginal mouth spines 7 or 8, similar to adambulacrals, basally webbed; on the convex outer part of mouth-plates, 3-5 slender subambulacrals, the inner slightly the longer.

Tube-feet with sucking disk about as broad as column.

TYPE LOCALITY. St. 1563, Marion Island, 46° 48.4' S, 37° 49.2' E, 101-106 m., 1 specimen.

REMARKS. The similarity of this species to *L. furcilliger*¹ Fisher, Alaska to Galapagos Islands, 192-1100 fathoms, has been mentioned in the diagnosis. In that form the abactinal 2- and 3-pronged glassy spinelets, 1-1.2 mm. long, radiate in all directions forming a subspherical group. The spinelets of the marginal paxillae are not markedly unequal in length nor is the pedicel of the inferomarginals compressed at the end. A series of spaced actinal platelets extends along the ray. In *L. suluensis*² Fisher the pedicels of abactinal and marginal paxillae are conspicuously shorter than the spinelets, which are not trifurcate; the subambulacral spines are much longer than the furrow spines, and are longer than marginal paxillae with their spines. *L. marionis* is probably most nearly related to *L. quadrispinus* Clark from the Cape region, South Africa. Clark compares *quadrispinus* to *L. furcilliger* but it is more like *L. stellans* Sladen. There is a well-developed series of actinal paxillae extending nearly to tip of ray and 8-12 similar but smaller paxillae in the remainder of the interradiial area. Clark states that *quadrispinus* has much more numerous actinal paxillae than has *stellans*. But *stellans* also has a series of well-developed actinal paxillae extending to end of ray, while *marionis* has none. I think *quadrispinus* and *stellans* are closely related. In the matter of proportions and general habit my specimens of *stellans* agree with Clark's rather poor figures; and in addition to the series of actinal paxillae adjacent to the adambulacral plates there are 4-10 small paxillae in each interradiial angle—a number which overlaps the 8-12 of *quadrispinus*. In *stellans* the furrow spines are generally 4, 3, 2; but also, as in *quadrispinus*, there may be 5 or 6³ at base of ray. In *quadrispinus* the reported number of

¹ Fisher, 1911, p. 334, pl. 79, figs. 1, 2; pl. 114, figs. 1-1g; pl. 116, fig. 5.—1930, p. 198.

² Fisher, 1919, p. 449, pl. 123, fig. 2; pl. 124, fig. 3; pl. 132, figs. 8, 8a.

³ Mortensen, 1933, p. 272.

subambulacra is 4, 3, 2; in *stellans* it is 6 or 5, and 4 only sporadically, or at tip of ray. The abactinal paxillar spinelets of *stellans* (0.7–0.9 mm. long) have 5 or 6 sharp prongs (Fig. E, 3a) rather than the 3 or 4 of *marionis*. Ludwig's figures (1903, pl. 3, fig. 23) do not represent typical abactinal spinelets of the *stellans* of Falkland region but are similar to Koehler's figures of the spinelets of *L. pentactis* Perrier (Koehler, 1920, pl. 68, fig. 3). Spines of *L. quadrispinus* have not been figured.

Out of this emerges the probability that *stellans* and *quadrispinus* are representative small species of the eastern and western hemispheres, connected by a pan-Antarctic species (or series of small species) of which *marionis* is a northern representative.

Lophaster gaini Koehler

Lophaster gaini Koehler, 1912, p. 42, pl. 4, figs. 4, 5, 12, 13.—1920, p. 143, pl. 31, figs. 8, 9; pl. 66, fig. 8.

St. 187. Neumayr Channel, Palmer Archipelago, 64° 48' 30" S, 63° 31' 30" W, 259 m., mud, 1 specimen.

St. 599. West coast of Adelaide Island, 67° 08' S, 69° 06½' W, 203 m., 1 specimen.

Koehler has fully described and figured this species, which appears to have no very close relatives. One might quite naturally assume it to be an Antarctic equivalent of *L. stellans* of the Cape Horn-Falkland region but this seems to be definitely not the case. *L. gaini* has highly characteristic abactinal spinelets which are needle-like and end in a single hyaline point, while in *stellans* these spinelets are characteristically 3- or 4-pronged as illustrated by Ludwig (1903) and Koehler (1920, pl. 68, fig. 3). I have verified the spine characters of both species. In *L. gaini* the marginal, especially the inferomarginal, spines are unusually coarse, rather few in number, and acicular in form (see Koehler, 1920, pl. 31, fig. 8). About 5 of the spines are conspicuously larger than the others and on the outer part of the ray they form a transverse comb, flanked on the adoral side by a group or series of 5 or 6 shorter spines. On the outer third of the ray the marginal plates and spines resemble those of *Ganeria*.

TYPE LOCALITY. South Shetland Islands (King George Island) 420 m., mud and stones.

DISTRIBUTION. South Shetland Islands, Palmer Archipelago, and Adelaide Island, 203–420 m. Adélie Land, 318–400 fathoms; Queen Mary Land, 110 fathoms. Probably a continuous circumpolar distribution.

Lophaster densus sp. nov.

(Fig. E, 4–4c; Plate XIII, figs. 2, 3)

DIAGNOSIS. Rays 5; R 19 mm., r 7.5 mm., br 8 mm. Disk rather high and rays strongly convex, the marginals being on the actinolateral border; paxillae close-set, low, compact, the abactinal view suggesting a short-rayed *Leptychaster*; marginal paxillae close-set, low, not projecting as in typical *Lophaster*, the very even surface of the abactinal spinulation passing without a break into that of inferomarginal paxillae; actinal surface with well-developed actinal interradiar areas and suggesting a five-rayed Solaster.

DESCRIPTION. The paxillae are low, flat-topped, spaced less than the diameter of the crown of compactly placed short spinelets which form a co-ordinated group. Spinelets 15–30, usually 20–30, to a paxilla, slightly longer than the low tabulum which springs from a 4-lobed base. Spinelets with 3 deeply excavated sides, broadening conspicuously to a convex truncated summit beset with numerous points. Spinelets 0.3–0.4 mm. long and not obviously bound together by membrane, although there is a very delicate membrane at the base, continuous with the thin dermal investment of spinule.

The abactinal plates are squarish with rounded corners and shallowly excavated sides. They strongly overlap by these incipient lobes and the very small interstices accommodate a single papula. Plates form fairly regular transverse series, the regularity of which is interrupted at midradial line.

Madreporite 1.5 mm. in diameter, situated in middle of r and hidden by paxillae.

Superomarginals alternate with inferomarginals. They are conspicuously larger than adjacent small abactinals but on outer part of ray the difference is not so marked. The crown does not extend above the level of the abactinal paxillae, although the spinelets are slightly coarser and number about the same as on large abactinal paxillae (i.e. 20–30).

Inferomarginal paxillae 20, conspicuously larger than the superomarginals, with about the same number of still heavier spines which increase conspicuously in size from the dorsal to ventral margin of tabulum. The inferomarginals have a shorter pedicel and more compact appearance than in *L. stellans*. The largest spines are about 0.6 mm. long, while a few small ones from dorsal margin are as small as 0.3–0.4 mm. (Fig. E, 4b).

The actinal interradiar area is well developed for so small a specimen, containing 3 chevrons of plates. The first series extends to end of ray. The plates on the disk have 6–9 divaricate spines on a slight convexity. Beyond the second or third inferomarginal the plates become spaced and carry 3 or 4 spinelets, then 2, and finally only 1. At middle of ray there are 6 actinals to 3 inferomarginals. The second chevron does not extend beyond the second inferomarginal; while the third consists of 3–5 plates adjacent to the first inferomarginal of neighbouring series.

Adambulacral furrow spines 5, 4, 3, 2 from base to end of ray. They are rather coarse, subterete, round-tipped when covered with membrane. The 2 or 3 median are much longer than the laterals of the comb and all are united by web to mid-height. Subambulacrals in a curved transverse series of 4 or 5 spines increasing in size from outer to inner. The inner 2 or 3 are much coarser but not much longer than the median furrow spines and are from 1 to 1.2 mm. long (Fig. E, 4c).

The oral plates are characteristic of *Lophaster* in form and armature; marginal spines 6–8, webbed increasing in length to innermost, which, being slightly longer than subambulacrals, are the largest spines on body. Suborals 9 or 10 in two poorly defined series adjacent to median suture and widely spaced from the marginal spines.

Gonads interradiar, opening on upper border of first superomarginal plate. There is a slender calcified interbrachial pillar extending from odontophore to abactinal wall, but no membranous septum joins this pillar to the wall of body at interbrachium, as in *Crossaster*. There is no trace of the characteristic muscles of *Myoraster*.

TYPE LOCALITY. St. 175, Bransfield Strait, South Shetlands, $63^{\circ} 17' 20''$ S, $59^{\circ} 48' 15''$ W, 200 m., mud, stones, gravel. The type and a specimen with R 7.5 mm. Taken also at St. 1948, north-east of Clarence Island, $60^{\circ} 49.4'$ S, $52^{\circ} 40'$ W, 490–610 m., 1 specimen.

DISTRIBUTION. Known only from South Shetland Islands.

REMARKS. The specimen having R 7.5 mm. has the arched abactinal surface and neat appearance of the type, but the actinal interradii areas are very small. Only the first adambulacral plate has 5 furrow spinelets; subambulacrals proximally 4. The number of abactinal spinelets is of course variable but is of the order of 15 on the larger plates.

The specimen from St. 1948, received long after the original collection, has R 19 mm., r 8 mm., br 9 mm., and shows no important variations.

L. densus is very different from any described species. As stated in the diagnosis its dorsal aspect is that of a *Leptychaster*, while the close-set marginals on the actinolateral border are so different from those of *L. stellans* that one may say the divergence in general habit is as great as that between *Solaster endeca* and *Crossaster papposus*.

The type was dredged at the same station with *Myoraster antarcticus*. Of course this species is distinguished at once by its generic peculiarity, the actinolateral muscle. But superficially the paxillae are rather similar, though the spinelets differ in form. The inferomarginals of *Myoraster* are much more prominent than those of *densus* and the actinal interradii areas are distinctly smaller.

Genus *Paralophaster* nov.

DIAGNOSIS. Five-rayed Solasteridae closely similar to *Lophaster*, but without differentiated superomarginal paxillae. Type *Solaster godefroyi* Koehler.

REMARKS. Koehler described 4 species of Antarctic Solasteridae having five rays but differing from *Lophaster* in lacking differentiated superomarginal paxillae. These species are: *Solaster lorioli*¹ from 2500 fathoms, $67^{\circ} 33'$ S, $36^{\circ} 35'$ W; *S. godefroyi*² from 250 to 400 m., southern Bellingshausen Sea and off Queen Mary Land; *S. incertus*,³ Kerguelen, shallow water; *S. asperatus*,⁴ 110 fathoms, off Queen Mary Land.

Since Koehler's *Solaster* included also *Crossaster*, it is probable that he had the latter type in mind. In *Crossaster* the paxillae are penicillate and spaced; the superomarginal are subequal to the abactinal, while the inferomarginal are abruptly much larger. In *Solaster* (e.g. *S. endeca*) there are definite, differentiated superomarginal paxillae, although they are much smaller than the inferomarginals.

Paralophaster has the appearance of a 5-rayed *Crossaster*, but it lacks the membranous interbranchial septum of *Crossaster* (absent also in *Lophaster* and *Solaster*). The abactinal paxillae are arranged in oblique transverse rows as in *Solaster*, *Lophaster*, *Myoraster*, but not as in *Crossaster*.

¹ Koehler, 1908, p. 558, pl. 4, figs. 40, 41.

² Koehler, 1912, p. 50, pl. 4, figs. 2, 6, 9, 10, 11; 1920, p. 153, pl. 31, fig. 1; pl. 35, figs. 1–4; pl. 66, fig. 9.

³ Koehler, 1917, p. 40, pl. 5, figs. 2, 3; pl. 9, figs. 21, 22.

⁴ Koehler, 1920, p. 157, pl. 33, figs. 8, 9; pl. 65, fig. 3.

Paralophaster godefroyi, *asperatus* and *lorioli* form a homogeneous group. The only known specimen of *lorioli* is immature (R 22 mm., r 5 mm.).

Solaster incertus is probably not a *Paralophaster*. The type is small, dried, and imperfect (R 15 mm., r 5.5 mm.). There are no differentiated superomarginals.

Paralophaster godefroyi meseres n.subsp.

(Fig. F, 2-2*b*; Plate XII, figs. 2, 3)

DIAGNOSIS. Differing from *P. godefroyi* (Koehler) in the following particulars: adambulacral furrow spines 2 (3 on first few plates and 1 on distal); inferomarginal spines at middle of ray 20-25; abactinal paxillae with short pedicel carrying, on disk and base of rays, from 5 to 8 subequal, delicate, spinelets irregularly denticulate on the distal half; paxillae of outer half of ray with 2-5 spinelets; marginal mouth spines 6 or 7, suborals 3 or 4; actinal intermediate spines 2-5. R 28 mm., r 8 mm., $R=3.5r$; br at interradius, 9 mm.

DESCRIPTION. In the specimens of *godefroyi* from the type locality, the abactinal paxillae carry 2-4 central, and 6-10 peripheral spinelets, smaller than the central. In *meseres* the spinelets are fewer and very nearly equal; there is no differentiated central group. The superomarginal paxillae in both species are not distinguishable from the other abactinal paxillae. In the large example of *godefroyi* from off Queen Mary Land the abactinal paxillae have 15-20 spinelets while the large inferomarginals carry 15 spinelets—the same number as in the much smaller type. The obviously larger number of inferomarginal spinelets of *meseres* is the more surprising since the abactinal paxillae have fewer spines than in *godefroyi*.

In *godefroyi* the abactinal spinelets (0.9-1 mm. long) are three-edged (prismatic with deeply excavated sides) and taper to a sharp point or occasionally two (Koehler, 1920, p. 154, pl. 66, fig. 9*a*). The dorsal spinelets of *meseres* are structurally the same but the edge of the 3 flanges is sparsely and irregularly denticulated, as indicated by figures of 4 abactinal spinelets. Koehler's figures of *godefroyi* indicate that the 3 flanges are well developed but without lateral teeth. In *meseres* the inferomarginal spines are smooth edged with 1 or 2 slight denticulations at tip, usually on only one of the flanges. These flanges are better developed in *godefroyi*.

Actinal interradiar areas do not reach the distal margin of second inferomarginal. They contain about 12 roundish plates which carry a divaricate group of 3-6 very slender spinelets. A single series of very small actinal plates extends two-thirds length of ray. Beyond fourth or fifth inferomarginal there is only one plate to each inferomarginal, at its adoral end.

Adambulacral furrow spines basally webbed, long and slender, 2 to a plate except for the first to third plates, which carry 3, and those near tip of ray, which carry 1. Subambulacrals proximally 4, varying to 3 on middle range of ray; then on distal third of ray, 5. The spines are basally webbed and this web is continued from the innermost suboral to the base of the distal furrow spine. On the most distal plates, with 1 furrow spine, the

armature consists of a transverse webbed comb of 6 spines, the innermost being the furrow spine. The adambulacral plates are much broader than long, and the muscular interval between the plates is twice as wide as the spine-bearing crest of the plate. The suboral combs occupy only the inner of furrow half of this crest, so that there is a definite spineless zone along ray between the outer subambulacral and the base of the inferomarginal paxillae. The longest subambulacral spines are 1.8 mm. and 3 are figured for comparison with *S. godefroyi*. Furrow spines proximally are subequal to the subambulacrals; distally they are definitely shorter.

Marginal mouth spines 6 or 7, similar to adambulacrals; suborals smaller, 3 or 4, in a single series along median suture.

TYPE LOCALITY. St. 1652, Ross Sea, 76° 56.2' S, 178° 35.5' W, 567 m.

SPECIMENS EXAMINED. The type.

REMARKS. *Paralophaster godefroyi* was described from 3 small specimens (R 37, 14, and 4 mm.) taken by the second Charcot Expedition near Alexander I Island and west of Charcot Island, 250–400 m., sandy mud, pebbles and rocks (Koehler, 1912, p. 50, pl. 4, figs. 2, 6, 7, 9, 10, 11). A larger specimen, having R 70–80 mm. was described and figured by Koehler from off Queen Mary Land, 64° 32' S, 97° 20' E, 110 fathoms (1920, p. 153, pl. 31, fig. 1; pl. 35, figs. 1–4; pl. 66, fig. 9).

In the same dredge haul with this large specimen was taken a very immature *Paralophaster* which Koehler has described as *Solaster asperatus* (1920, p. 157, pl. 33, figs. 8, 9; pl. 65, fig. 3; R 8.5 and 9 mm., r 4 mm.). The denticulated spinelets of the abactinal paxillae are somewhat similar to those of *meseres*, but the inferomarginal are not. Even in such a tiny specimen Koehler found 12 spinelets on the largest paxillae and 10 on the others. Koehler states that the inferomarginal paxillae “se distinguent de celles du reste de la face dorsale, non pas par le développement particulier de leurs pignants qui ne sont pas plus grands que les autres, mais par l'épaississement et l'allongement de leur tige”. In *meseres* the inferomarginal spinelets are not only larger and more numerous than those of the abactinal paxillae but they are of a different form. They lack the conspicuous denticulations characteristic of the abactinal spinelets.

This small type of *Paralophaster asperatus* has 4 furrow spines, and 3 subambulacrals “très forts et allongés”. Koehler states that the spines have “une structure analogue à ceux des paxilles dorsales, mais ils sont plus forts et leurs denticulations terminales sont un peu plus nombreuses”. That is, the denticulations are in excess of 2–4 on each of the 3 flanges. In *meseres* the subambulacrals have only a few terminal denticles as shown in 2*b*, left, but exceptionally as many as shown in 2*b*, right. They seem nearer to the typical subambulacral of *godefroyi* figured by Koehler (1920, pl. 65, fig. 9, *d*).

Finally, in spite of having more numerous adambulacral furrow spines than *meseres*, *asperatus* has only 5 marginal mouth spines. In respect to general appearance it is evident that *meseres*, with its prominent inferomarginal paxillae and their numerous spinelets conspicuously longer than the abactinals, more nearly resembles *P. godefroyi*. But it must be remembered that the specimen of *asperatus* is too young to afford a definitive picture of the species. It appears, however, to be distinct from *godefroyi*.

Genus *Solaster* Forbes

Solaster Forbes, *Mem. Wernerian Nat. Hist. Soc.*, VIII, 1839, p. 120. Type *Asterias endeca* Linnaeus.

Solaster regularis Sladen

Solaster regularis Sladen, 1889, pl. 60, fig. 1; pl. 62, figs. 5, 6.—Fisher, 1911, p. 323.

Crossaster australis Perrier, 1891, p. 113, pl. 10, figs. 1a-1d.

Solaster australis Ludwig, 1905, p. 63.—Fisher, 1911, p. 323.

St. WS 80. Falkland Islands, 50° 57' S, 63° 37' 30" W, 152-156 m., fine dark sand, 2 specimens.

St. WS 97. Falkland Islands, 49° S, 61° 58' W, 146-145 m., 1 specimen.

St. WS 108. Falkland Islands, 48° 30' 45" S, 63° 33' 45" W, 118-120 m., fine dark sand, 1 specimen.

St. WS 243. North-east of Falkland Islands, 51° 06' S, 64° 30' W, 144-141 m., coarse dark sand, 2 specimens.

St. WS 773. East of Cape Tres Puntas, 47° 28' S, 60° 51' W, 291 m., 1 specimen.

St. WS 804. Falkland Plateau, 50° 22 $\frac{3}{4}$ ' S, 62° 49' W, 150-143 m., 1 specimen.

St. 824. South-east of East Island, Falkland Islands, 52° 29 $\frac{1}{4}$ ' S, 58° 27 $\frac{1}{4}$ ' W, 146-137 m., 1 specimen.

Eight specimens have 9 rays and one has 10 rays (St. WS 243). The type has 8 rays, Ludwig's specimen 10, Perrier's, 9 or 10.

This species is as variable as the north Pacific *Solaster paxillatus* Sladen and *S. borealis* Fisher. As in these species, there is a form with small paxillae, one with large, and intermediates. Sladen's figure represents an aberrant extreme, just as his figure does in the case of *paxillatus*, in which, also, the rays vary from 8 to 10.

There are scarcely 2 specimens of *regularis* from different localities which are alike. The example from St. WS 824 (R 84 mm., r 25 mm., br 17 mm.) has relatively large, close-set paxillae with numerous (e.g. 18) slender, sometimes terminally expanded, thorny spinelets which appear stout, blunt and papilliform on account of the soft pulpy investment. The proximal furrow combs have usually 5, long, slender, basally webbed spines, also appearing blunt and stout on account of the sheath. These diminish to 3 on outer part of ray. Proximally the transverse, curved, subambulacral comb usually has 6 slightly longer, heavily sheathed spines; distally there are 5. In a specimen from St. WS 80 there are 7 with a smaller eighth at outer end of series. These spines are stout, subterete, tapered, but usually appear coarser and blunter than they really are on account of the sheath. Each mouth-plate carries about 9 marginal spines, the inner enlarged and terminally bifid, while parallel to median suture there are 7 or 8 suboral spines, the inner of which is subequal to the 2 "teeth". Inferomarginals of conspicuous size, broader than long, much like those of *S. paxillatus* (Fisher, 1911, pl. 88). The first 10 correspond to the first 17 or 18 adambulacrals.

There is a specimen from St. WS 243 (R 100 mm., r 36 mm., br 26 mm.) referable to the same forma but, owing to inflation of disk and rays, the paxillae are not so closely placed. The sheath of all the spines is unusually thick and pulpy.

Forms with small paxillae are represented by figures of Sladen's type and those of *Crossaster australis* Perrier. In the latter the dorsal integument is unduly shrunk by

preservation or drying. Specimens from Sts. WS 80 and WS 97 are examples. Paxillae carry usually 6–10 delicate but “pulpy” sheathed spinelets; R 73 mm., r 22 mm., br 12–13 mm. Slenderer, less inflated rays among other things allow the inferomarginals to stand out more prominently and alter the general appearance. When the ray is strongly inflated the marginals of the proximal half or two-thirds of ray are hidden when viewed directly from above, whereas in a slender-rayed form, such as that having R 110 mm., br 17–19 mm. (St. WS 108), all or nearly all can be seen from above, and stand out prominently on the sides of the ray. Such a specimen seems to belong to an entirely different species from the large puffy example from St. WS 243.

The stomach of a large specimen from St. WS 243 contained the remains of a *Pteraster*.

TYPE LOCALITY. Challenger Station 308, south of Wellington Island, Chile, $50^{\circ} 8' 30''$ S, $74^{\circ} 41'$ W, 175 fathoms, blue mud.

DISTRIBUTION. Cape Horn region and Falkland Plateau, north on the Pacific side to 50° and on the Atlantic to $47^{\circ} 28'$; 65–350 m., mud, sand.

Solaster regularis subarcuatus Sladen

Solaster subarcuatus Sladen, 1889, p. 455, pl. 60, fig. 2; pl. 62, figs. 7, 8.—Döderlein, 1928, p. 296, pl. 12, fig. 4.

Solaster octoradiatus Ludwig, 1903, p. 25, pl. 3, figs. 21, 22.—Bell, 1908, p. 11.

St. 170. Off Cape Bowles, Clarence Island, $61^{\circ} 25' 30''$ S, $53^{\circ} 46'$ W, 242 m., rock, 2 specimens.

Both specimens have 8 rays. The type has 9 rays; 5 specimens reported by Ludwig had 8 rays and one had 7 rays. Bell's specimen, which I have in hand, is 8-rayed, as was Döderlein's specimen.

The larger of the 2 specimens has R 40 mm., r 14 mm. The abactinal paxillae are a little larger than those of the type. The largest have 9 or 10 peripheral and 4–7 central, blunt, denticulate spinelets. The papulae are not numerous in the close meshes of the skeleton—usually 3 or 4 to a group. The mouth-plates each have about 9 marginal spines of which the 3 inner are decidedly elongated. Bell's specimen from Coulman Island has 7 (R 31 mm.) while the small example from St. 170 also has 7 (R 10 mm.). The ambulacral plates of this specimen have, proximally, 2 furrow spinelets, distally only 1, while the larger specimen has 5, 4, 3, 2, 1, from base to extremity of ray. The transverse subambulacral combs contain 5 or 4 stout spines, conspicuously longer than the marginal. In the young specimen there are usually 4.

Subarcuatus is obviously close to *regularis*. Indeed the resemblance is apparent from Sladen's figures which stand side by side on Pl. 60, and these represent but random samples. When one observes the latitude of variation in *regularis* he is somewhat put to it to discover wherein *subarcuatus* differs. Both “species” have forms with larger and smaller paxillae; both have the same general appearance and the same number of rays. So far as is known *subarcuatus* does not grow so large as *regularis*; there are 4 or 5, rather than 6 or 7, subambulacral spines; and in comparison to the latter the furrow spinelets are much shorter, especially in the Coulman Island specimen. In *subarcuatus* the

abactinal paxillar spinelets are shorter and stouter, somewhat clavate in general contour, with the rather numerous thornlets at the tip, and usually only a slight distance below the tip. In *regularis* the spinelets are usually slender, somewhat tapered in general contour with far fewer terminal spinelets and other prominent thorns occurring irregularly on the side of shaft half-way to the base (but not in all spinelets). These are not invariable characters but rather the habit of the two forms.

I think it will be convenient to maintain *subarcuatus* as the antarctic representative of *regularis*; but as I have indicated in the synonymy there seems to be no place for *O. octoradiatus*.

TYPE LOCALITY. Challenger St. 150. Between Kerguelen and Heard Islands, $52^{\circ} 4' S$, $71^{\circ} 22' E$, 150 fathoms, coarse gravel, bottom temperature $35.2^{\circ} F$.

DISTRIBUTION. Probably circumpolar. Between 80° and $88^{\circ} W$, 70° – $71^{\circ} 18' S$, 450–500 m. ('Belgica'); Coulman Island, $73^{\circ} 30' S$, $170^{\circ} E$, 100 fathoms; South Shetland Islands, 242 m. ('Discovery').

Genus *Crossaster* Müller & Troschel

Crossaster Müller and Troschel, *Monatsber. preuss. Akad. Wiss.*, 1840, p. 103. Type *Asterias papposa* Linnaeus.

Crossaster penicillatus Sladen

Crossaster penicillatus Sladen, 1889, p. 446, pl. 60, fig. 5; pl. 62, figs. 9, 10.—Koehler, 1908, p. 560 (Gough I.).—Bell, 1905, p. 249.—Clark, 1923, p. 295.—Mortensen, 1933, p. 272.

St. H. Cape Trawler, $34^{\circ} 4' S$, $17^{\circ} 36' E$, 272–402 m., 1 specimen.

The specimen has 10 rays; R 65 mm., r 20 mm., br 11–14 mm. Clark's specimens had from 8 to 10 rays—the young 8 or 9, and the adults (R 55–60 mm.) 9 or 10 rays. The furrow spines are long and slender, basally webbed, 5 at the base of ray, then 4, 3, 2, and finally 1 near the end. This single spine is co-ordinated with the curved transverse comb so that the adambulacral armature consists of essentially a single transverse series, which, so far as the 3 innermost spines are concerned, descends somewhat upon the furrow face of the plate. The subambulacral spines are long, slender, tapered and pointed. The combs are transverse or obliquely transverse, curved, with the convexity adoral. The first few combs consist of about 5 basally webbed spines, rapidly increasing to 7 and 8; then to 7, 6, 5 on outer fourth of ray. The spines stand on a curved convexity or crest of the plate, which becomes more prominent on the outer part of ray. Each mouth-plate has 10 furrow spines, the inner 3 or 4 conspicuously longer than the others, and about 10 long subambulacral spines. Abactinal spinelets are numerous, long, very delicate. It will be seen from the above that the spines are not much more numerous than in Sladen's type, in which R is 34–36 mm.

TYPE LOCALITY. Challenger St. 135C, off Nightingale Island, Tristan da Cunha, 110 fathoms.

DISTRIBUTION. Tristan da Cunha and Gough Islands, South Africa; Marion Island; 80–800 m., sand, mud. The range is therefore in the sector between $40^{\circ} E$ – $15^{\circ} W$ and 33° – $47^{\circ} S$.

Genus *Myoraster* nov.

DIAGNOSIS. Rays 5. Differing from *Solaster*, *Crossaster*, and *Lophaster* in having a specialized internal longitudinal muscle lying between adambulacral and superomarginal plates and extending from end of ray to interbrachial angle, whence it continues to the tip of adjacent ray. Abactinal paxillae resembling those of *Lophaster*; marginal plates of *Solaster endeca* type; actinal and adambulacral armature not essentially different from that of *Lophaster*. Type, *Lophaster antarcticus* Koehler.

REMARKS. The specialized actinolateral muscle is the most characteristic feature of this genus, which otherwise resembles a combination of *Solaster* and *Lophaster*. The marginal plates, for example, are like those of typical *Solaster*, since the inferomarginal paxillae are compressed, somewhat fan-shaped, while the superomarginal paxillae are only a trifle larger than the abactinal paxillae and usually stand above the interspaces between the inferomarginals, as in *Solaster endeca*. In typical *Lophaster* the conspicuously enlarged superomarginal paxilla stands above the inferomarginal and the combined plates form a single strong dorsoventral calcareous ridge, very apparent when viewed from the coelom.

It is of course not possible to make a definitive evaluation of such a character as the actinolateral, or marginal, muscle which appears thus in an isolated species. The slight rudiment of it, as a faint narrow band, can be detected in some specimens of *Solaster endeca*, where it can hardly be of functional importance. I can find no trace of it in *Lophaster*. An actinal muscle layer, of which at least a part is homologous with this marginal muscle, occurs in *Cuenotaster*, a genus very distinct from all other Solasterids.

An interesting feature of the type species is a specialized spinelet terminating in 3 lobes, rather than 3 sharp prongs. The variations have been fully figured by Koehler (1920, pl. 67, fig. 3). This special spinelet occurs in addition to the normal spinelets with 3 sharp terminal prongs, and has not been described in any other Solasterid.

It is possible that *Solaster incertus* Koehler (1917, p. 40, pl. 5, figs. 2, 3; pl. 9, figs. 21, 22) belongs to this genus. The type and only known specimen from Kerguelen is too small (R 15 mm.) to indicate adult characters.

Lophaster tenuis Koehler, based upon a single small specimen (R 21–22 mm.) from 64° 32' S, 97° 20' E, 110 fathoms, has very special spine characters which separate it from *antarcticus*. It may belong to *Myoraster* (Koehler, 1920, p. 151, pl. 32, figs. 1–7; pl. 68, fig. 5).

Myoraster antarcticus (Koehler)

Lophaster antarcticus Koehler, 1912, p. 46, pl. 3, figs. 4, 5.—1920, p. 144, pl. 32, figs. 8–11; pl. 33, figs. 3, 4; pl. 67, figs. 1–5; pl. 68, figs. 1, 2.—1923, p. 75.

St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud, stones, 4 specimens.

St. 175. Bransfield Strait, South Shetlands, 63° 17' 20" S, 59° 48' 15" W, 200 m., mud, stones, gravel, 1 very small specimen.

St. 181. Schollaert Channel, Palmer Archipelago, 64° 20' S, 63° 01' W, 160–335 m., mud, 5 specimens.

St. 182. Schollaert Channel, Palmer Archipelago, 278–500 m., 1 specimen.

St. 371. One mile east of Montagu Island, South Sandwich Islands, 99–161 m., 1 specimen.

St. 599. West coast of Adelaide Island, 67° 08' S, 69° 06½' W, 203 m., 3 specimens.

The largest specimens measure as follows: St. 181, R 142 mm., r 42 mm., br 45 mm.; St. 148 (South Georgia), R 160 mm., r 46 mm., br 50 mm.

Kochler has fully described and figured the external features of this species, including the characteristic spinelets. His type specimen from Adelaide Island and Alexander I Land were all small, none exceeding R 28 mm. However, the Australasian Antarctic Expedition secured material from off Adélie Land, the largest specimen of which has R 120 mm.

St. 599 is very near the type locality and the largest specimen has R 74 mm., r 21 mm., br 22 mm., and conforms well to Kochler's description. A curious feature of this specimen, as well as others from different localities, is the position of the subambulacral comb which consists of 3-5 basally webbed spines. The normal position of the comb is probably a slightly curved, obliquely transverse, line from the outer adoral to the inner aboral corner of the plate. However, this line shifts so that the slightly curved comb (convex side adoral) is almost at a right angle to furrow; or the axis of the comb may shift so that the comb becomes more nearly parallel with the furrow series and closer to it. This last posture is rather characteristic of the specimens from Schollaert Channel, Palmer Archipelago, although oblique transverse combs are found—especially on the outer part of ray. In contrast the specimens from other localities such as Adelaide Island, South Sandwich Islands, South Georgia, while showing the extremes of variation have the majority of the subambulacral combs obliquely cross-wise on the plate.

A variable feature of the species is the size of the actinal interradiar area which is associated with size of the disk. The type form has the smallest disk (Kochler, 1912, pl. 3, fig. 5, young; 1920, pl. 32, fig. 9, adult). The disk may become much broader, and the interbrachia more rounded than in Kochler's pl. 33, fig. 4 (1920), with correspondingly enlarged actinal interradiar areas. This holds true for all the South Georgia specimens, the large specimen from St. 181, that from St. 182, but not for the example from St. 371 (R 122 mm.). It is difficult to express the difference in terms of actinal plates, as they are of about the same number in large specimens but differ in spacing. Eight to ten paxillae may be counted along the interradiar line from mouth-plates to margin. The series parallel to furrow is not always very regular, outside the first, which reaches to within a short distance of tip of ray. In the triangular actinal interradiar area there are usually about 6 chevrons of paxillae, with a few irregular additional paxillae next to the first inferomarginals.

The abactinal skeleton is a close mesh, fairly regularly 4-sided on the lateral parts of the area but irregular along a broad radial band. The lateral abactinal plates (the bases of the paxillae) have 4 rather long lobes which touch or overlap 4 neighbouring plates. In the radial area the plates are irregular and are frequently 3- to 5-lobed, with short connecting ossicles in old specimens. The papulae are found all over the ray and disk and there are commonly 2-5 to an area in large specimens, but only 1 to an area in small examples (and on outer third of ray of large specimens).

The interbrachial calcified pillar is slender and flexible, and expands slightly where it joins the abactinal skeleton. The membranous septum in which the pillar lies expands

fan-wise at the dorsal end, but below is scarcely more extensive than the pillar. It does not extend interradially to the margin as there is a wide free passage between the adjacent rays.

Gonads are interradial in position and empty dorsally about one-fourth r from interbrachial angle.

In one of the large specimens from South Georgia the abactinal plates of the disk and radial region of proximal half of ray have disappeared along with the basal portion and in some cases all of the shaft of the paxilla. The condition is possibly pathological, as in the other large example from the same station the skeleton is intact.

The remarkable muscular system which differentiates this species from *Lophaster*, *Solaster* and *Crossaster* is essentially a compound bundle of conspicuous size which lies at the lower end of the ambulacral ossicles, against the adambulacral plates to each of which a strand is attached. It therefore is very slender at the end of ray but rapidly increases in size toward the base. At the distal limit of the actinal interradial area it leaves the adambulacral plates and follows the ambitus as a continuous structure into the adjacent ray where it follows an identical course to the tip. Over the coelomic surface of the actinal interradial area a thinner sheet of muscle, composed in part of strands originating in the marginal bundle, passes to the adambulacral plates. In addition, narrow muscles which branch off abundantly from the conspicuous dorsal radial muscle, on reaching this longitudinal muscle, become transformed into thin raised ridges which cross the marginal muscle. Some of these attach themselves to the adambulacral plates, while others unite and continue (as a fairly symmetrical series of ridges) between the lower ends of the ambulacrals. These ridges are conspicuous across the actinal interradial area. The fascicles of the marginal muscle (which is the pertinent innovation) are therefore roughly at right angles (and somewhat covered by) these extensions of the normal dorsal muscular system.

In a specimen from St. 371 having R 120 mm. the marginal muscle measures at the interradius 3.5 mm. dorso-ventrally, by 2.5 mm. horizontally—after evident shrinkage from alcohol.

I have found what is probably the equivalent of the marginal muscle, in a very rudimentary form, in *Solaster endeca*. It is a very thin band, less than 1 mm. in width, lying under the actinal extension of the dorsal muscular system, described above as traversing at right angles the thick marginal muscle of *Myoraster*. There is no trace of the muscle in *Lophaster*, nor of the actinal interradial muscle sheet.

TYPE LOCALITY. Between Jenny Island and Adelaide Island, $67^{\circ} 43' S$, $70^{\circ} 45' 42'' W$, 254 m., rocks and gravel.

DISTRIBUTION. South Georgia to Adelaide Island ($67^{\circ} 43' S$) and off Adélie Land; probably circumpolar; 99–750 m.; rocks and mud.

Genus *Cuenotaster* M. P. Thiery

Leucaster Koehler (not Gauthier, 1887), 1912, p. 54. Type *L. involutus* Koehler.

Cuenotaster Thiery, ex Koehler, 1920, p. 159.

Koehler by inadvertence compared *Leucaster* to *Crenaster* Perrier, a name without status but regarded as synonymous with *Dytaster*. He intended to write *Ctenaster* Perrier, 1884, which is also without status since it is preoccupied by *Ctenaster* Agassiz, 1835. *Ctenaster* Perrier, renamed *Laetmaster* by Fisher (*Smithsonian Miscell. Coll.*, LII, 1908, p. 88), contains only one species, *L. spectabilis*, dredged in the West Indies in 1920 fathoms.

Although in *Laetmaster* the abactinal plates are very numerous and independent as in adult *Cuenotaster*, the adambulacral armature consists of a furrow comb of about 5 spinelets, and a subambulacral comb at a right angle to furrow, after the common Solasterid pattern. The inferomarginal plates, less prominent and less widely spaced than in *Cuenotaster*, show no trace of the latter's characteristic actinal double transverse ridges, or keels, associated with the marginals. As in *Cuenotaster* the superomarginal paxillae are not differentiated. So far as I am aware the only known specimen of *Laetmaster* is the type which I have examined at the Museum of Comparative Zoology, Cambridge, Massachusetts.

Cuenotaster involutus (Koehler)

Leucaster involutus Koehler, 1912, p. 55, pl. 5, figs. 1, 2, 3, 6, 7, 10, 11.

Cuenotaster involutus Koehler, 1920, p. 159, pl. 33, fig. 5; pl. 65, fig. 4.—1923, p. 75.—Döderlein, 1928, p. 295.

St. 42. Off mouth of Cumberland Bay, South Georgia, 120–204 m., 4 specimens.

St. 45. Off Jason Light, South Georgia, 238–270 m., grey mud, 1 specimen.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122–136 m., green mud, stones, 2 specimens.

St. 148. Off Cape Saunders, South Georgia, 132–148 m., grey mud, stones, 2 specimens.

St. 167. Off Signy Island, South Orkneys, 244–344 m., green mud, 2 specimens.

St. 195. Admiralty Bay, King George Island, South Shetlands, 391 m., 7 specimens. This is the type locality.

St. 1952. Between Penguin Island and Lion's Rump, King George Island, South Shetlands, 367–383 m., 1 specimen.

St. MS 71. East Cumberland Bay, South Georgia, 120–60 m., 1 specimen.

Koehler has described and figured the external features of this species which is readily recognized by the single series of prominent, bristling, spaced, marginal paxillae from the base of which a double ridge passes to the adambulacral plates. The adambulacral armature consists of a transverse series of 4 or 5 bristling tapered spines—the furrow spine and the subambulacrals co-ordinated in a single series. In young examples the abactinal skeleton is a very irregular, open mesh, enclosing small isolated irregular plates. With advancing age (R 70 mm.) the plates of the mesh become entirely dissociated and immersed in the thick integument, which also increases in thickness with age. These plates are very unequal in size, irregular, longer than wide, with tapered ends.

Those which formed nodal points of the reticulum are lobed. The originally isolated platelets of the younger stage are the smallest among the dissociated elements and bear paxillae of secondary size. It is probable that the plates also alter in shape with age, as the lobes are less well marked in large specimens.

In young specimens, as Koehler points out, the low paxillar groups of spinelets are easily recognizable, but with age become involved in the thickening (glandular) epidermis and lose their identity, precisely as in *Perknaster*. In a specimen with R 35 mm., primary paxillae with upward of 12 short spinelets (see Koehler, 1920, pl. 65, fig. 4) can be differentiated from smaller and lower groups of 2-4 spinelets. The primary groups are elements of the continuous reticulum, while the others stand on the independent, secondary, platelets. In very small specimens the secondaries are few in number, and the meshes of the reticulum are naturally smaller in proportion to the size of the enclosing plates.

The papulae are fairly large, not closely placed, and occur all over the abactinal surface.

The dorsoventral interrarial, calcareous pillar is slender, flexible, and the upper end joins the abactinal surface about one-third r from interbrachial angle. A narrow membranous septum (of which it is a part) impinges on the stomach, but between pillar and interbrachium there is no septum.

Gonads open dorsally about half way between upper end of calcareous pillar and margin. In a specimen with R 78 mm. the large eggs are fully formed (1 April 1926, St. 42).

The actinal floor of both disk and rays is covered with a conspicuous sheet of muscle, which is continuous with a thinner dorsal layer. In the rays the actinal portion appears to be homologous with the marginal muscle bundle of *Myoraster*. Its coelomic face is crossed by oblique ridges of tissue, in part muscular as in *Myoraster*, which pass between the lower ends of the ambulacral plates. As dissepiments these die out on the side of ray but their muscular elements appear to be continuous with the branched dorsal system which overlies (as seen from coelom) the continuous thin sheet. The marginal muscle is not obviously differentiated from the ventral (longitudinal) sheet as in *Myoraster*.

The rays of *Cuenotaster* are very flexible and are sometimes coiled ventrally. It seems obvious that this special ventral sheet of muscle (as well as the dorsal sheet and the disconnected dorsal plates) co-operate in some special locomotor behaviour. The animal may perform undulating movements of the rays and walk on the tips of its extended podia, as do some species of *Luidia*.

A specimen from St. 42 was dull greenish grey in life.

TYPE LOCALITY. Admiralty Bay, King George Island, South Shetlands, 75 m.

DISTRIBUTION. Probably circumpolar. From south of Adelaide Island (68° S) to Shag Rocks, 60-391 m., mostly hard bottom (rocks, gravel, with mud); Emperor William II Land to Adélie Land (89° E to 142° E, 64° 32' S to 66° 50' S), 120-700 m.

Family KORETHRUSTERIDAE Danielssen & Koren

KORETHRUSTERIDAE Danielssen & Koren, 1884; Bell, 1892; Gregory, 1900; Fisher, 1905, 1911, p. 340 (*q.v.*).

KORETHRUSTERINAE Sladen, 1889; Perrier, 1904.

Spinulosa superficially resembling the Solasteridae but differing in lacking a calcified interbrachial septum, actinal intermediate plates, paxilliform inferomarginals; armature of adambulacral plates forms with that of inferomarginal a single transverse series of spines, never webbed; abactinal skeleton composed of roundish plates or lobed plates, in *Peribolaster* connected by slender ossicles forming an open mesh; abactinal plates bearing a tuft of acicular or flattened spatulate spinelets, either independent or united by a sacculus; mouth-plates resembling those of Pterasteridae, but spines never webbed.

Genus Remaster Perrier

Remaster (subgenus) Perrier, 1894, p. 161. Type *Korethraster palmatus* Perrier.

Remaster gourdoni Koehler

Remaster gourdoni Koehler, 1912, p. 60, pl. 5, figs. 4, 5, 9, 12; pl. 8, fig. 7.—1923, p. 76, pl. 9, fig. 1.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122–136 m., green mud and stones, 1 specimen.

St. 141. East Cumberland Bay, South Georgia, 17–27 m., 6 specimens.

St. 145. Stromness Harbour, South Georgia, 26–35 m., 1 specimen.

St. 159. South Georgia, 53° 52' 30" S, 36° 08' W, 160 m., rock, 19 specimens.

St. 170. Off Cape Bowles, Clarence Island, 61° 25' 30" S, 53° 46' W, 342 m., rock, 5 specimens.

St. WS 177. South Georgia, 54° 58' S, 35° W, 97 m., 1 specimen.

St. MS 71. East Cumberland Bay, South Georgia, 120–60 m., 1 specimen.

Large specimens, sexually mature, measure: R 10–12 mm., r 6–7 mm., measured to apparent interbrachial angle and not bottom of sulcus. Koehler's largest example measured R 11.5 mm., r 6 mm.

The external characters of this species have been described and figured by Koehler who was the first to accord the group generic rank. There is one unfortunate error in Koehler's description. He states (1912, p. 62): "Entre la rangée marginale ventrale et les plaques adambulacraires, s'étendent, sur toute la longueur des bras, deux rangées régulières de plaques latéro-ventrales, dont chacune porte un piquant composé, élargi à l'extrémité et comparable à ceux de la rangée marginale ventrale, mais moins épais et comprenant un nombre moins élevé de piquants élémentaires" (that is, each spine has fewer dorsoventral calcareous rods).

As a matter of fact there are no actinal intermediate (lateroventral) plates whatsoever. The very broad, but short adambulacral plates overlap the inferomarginal series, but do not correspond plate for plate with the latter. The proximal inferomarginal plates are also wide, but rapidly shorten beyond the basal third of the ray.

The two series of lateroventral spines of Koehler's description are in reality the outer 2 of the transverse series of 3 prominent subambulacral spines. On the proximal half of

the ray the plates usually carry a much smaller, fourth, furrow spinelet. The first adambulacral plate is much shorter than the second, and is wedged between the second plate and the mouth-plate. However, it carries 4 spines, but the inner subambulacral is forced to the furrow margin, so that there are apparently 2 furrow spines (the distal much the smaller). This accounts for the 2 furrow spines of the first plate, as described by Koehler.

If the actinal integument is gradually removed by means of sodium hypochlorite (strong alcohol being used to arrest the disintegration) it is possible to define clearly the boundaries of the adambulacral plates and their relation to the inferomarginals. The outer end of the adambulacrals overlaps, as a rule, the inner half of the ventral surface of a pair of inferomarginals. This alternation of the plates of the 2 series is not absolutely regular.

The narrow, obviously specialized, interradian sulcus which this genus has in common with *Korethraster* is bordered and sometimes concealed by 2 regular rows of paxillae. The groove is paved by 2 series of modified flattish abactinal plates closely in contact and of course devoid of tabulum and spines. These form a sort of fold, the edge of which is turned toward the coelom. They actually constitute a strong interradian arch, superficial in position, the lower end of which is joined to the odontophore by a pair of rather elongate flattish plates with rounded ends. These may represent the first inferomarginals. A true interbranchial septum of plates is lacking. The actinostome is wide and flexible, the frame plates being elongate. The gonads are interradian.

The abactinal plates have four well-developed lobes by which the plates imbricate regularly. In the smaller interspaces there is a single papula; in the larger, 1 or 2.

A highly characteristic feature of this genus is to be found in the curious scoop-shaped abactinal spines which form hollow funnel-shaped fascicles on each plate. Each fascicle is enclosed in a common sacculus, concave at the summit of the group. These have been well described by Koehler, who speaks of the longitudinal elements of the spines as "petits piquants élémentaires". This is satisfactory as a figure of speech; but there is no evidence whatever that broadened spines are compound in the sense of being composed of several ankylosed spinelets. Each very small spine is so modified that the elements are spread out in two dimensions, rather than crowded into the three dimensions of the ordinary cylindrical spine.

This type of spine occurs on the marginal and adambulacral plates of *Korethraster* but not on the abactinal plates.

Koehler intimates that the abactinal plates are not regularly arranged, but this idea is due in part to the slightly dishevelled condition of his material. The key to the arrangement is the specialized interradian sulcus. The plates are in fairly regular series parallel to this. For each ray therefore the plates are in chevrons, the odd, apical, plate of which is a carinal plate. The first chevron is formed by the plates bordering the sulcus of two neighbouring interradii and the apical plate is the primary radial or first carinal. The 5 primary radials are close to the anus (which is covered by 6 or 7 converging blunt calcareous valves or modified spines). Those spines of the paxilla on the side of the plate

toward the anus are conspicuously longer than those of the opposite half of the circle and thus suggest the arrangement in the "oscular" paxillae of *Pteraster*. When the paxillar spines of *Remaster* are spread to their fullest extent they nearly or quite touch those of neighbouring paxillae. The membrane forming the end of each fascicle is stretched taut and the abactinal surface has a tessellated appearance. The supradorsal branchial space is nearly as effectively protected from outside contamination as in *Pteraster*.

The actinal surface of *Remaster* is not strikingly different from that of *Korethraster*. The divergence is seen in the abactinal surface. Perrier's diagnosis of *Remaster* may be superseded by the following:

Korethrasteridae having 4-lobed abactinal plates united in a small-meshed skeleton with 1 or 2 papulae to each interspace; abactinal and superomarginal plates with a fasciculate, obconic group of specialized, broadened, often scoop-shaped, denticulate spines enclosed in a sacculus enveloping the whole group; no actinal intermediate plates; no true calcified interradiial septum; gonads interradiial; adambulacral plates short and broad with a simple transverse series of prominent subambulacral spines, and usually a small furrow spine.

TYPE LOCALITY OF *REMASTER GOURDONI*. $64^{\circ} 49' 35''$ S, $65^{\circ} 49' 18''$ W, off Port Lockroy, Palmer Archipelago, 70 m., mud and pebbles.

DISTRIBUTION. Graham Land (south-east of Seymour Island); Palmer Archipelago; South Shetland Islands; South Georgia; Shag Rocks; Falkland Islands; 10–342 m.

Genus *Peribolaster* Sladen

Peribolaster Sladen, 1889, p. 464. Type *P. folliculatus* Sladen.—Fisher, 1911, p. 341 (diagnosis; *vide infra*).

Peribolaster folliculatus Sladen

(Fig. C, 5)

Peribolaster folliculatus Sladen, 1889, p. 465, pl. 73, figs. 4–7.—Fisher, 1911, pp. 341, 343.—Koehler, 1920, p. 164.

St. 1562. Off Marion Island, $46^{\circ} 52' S$, $37^{\circ} 55' E$, 97–104 m., 1 specimen.

St. WS 81. North-west of North Island, West Falkland Island, 81–82 m., sand, 1 very large specimen.

St. WS 93. West Falkland Island, 133–130 m., grey sand, 1 small specimen.

The specimen from St. WS 81 is much larger than Sladen's type and of an entirely different form. It measures: R 90 mm., r 52 mm., br 60 mm. The rays at base are thus two-thirds R in breadth. The gonads are greatly developed, causing the very flaccid, collapsed, abactinal wall to bulge at either side of the base of ray, so that from the actinal aspect a considerable portion of it is visible beyond the superomarginal plates. This is not true of the smallest example (St. WS 93) which measures R 31 mm., r 12 mm. (to actual interradiial angle, not end of spines); br 16 mm. (measured to end of spines). Even this specimen has broader rays than Sladen's type but the difference is due largely to the somewhat longer abactinal spines. The extreme breadth of ray of the large specimen would be greatly lessened if the body were turgid and the abactinal wall

elevated. As the internal organs are badly macerated, it may well be that the body form is not at all what it would be in life.

I have figured (Fisher, 1911, pl. 115, fig. 5) the abactinal skeleton of *P. biserialis*. It seems obvious from an examination of a prepared sample of the large specimen that there is no fundamental difference between the two species. In *folliculatus* an increase in the number of cruciform primary plates does not keep pace with increase in size of the animal. As a consequence the tufts of spines become widely spaced and the skeletal intervals greatly enlarged. The slender, secondary, spineless ossicles lengthen and, instead of 1, 2 or 3 connect the nodal points of the skeletal net. The character of the spinelets is similar in the two species, 4 or 5 being a common number for each abactinal fascicle. In the large specimen the papulae are much more numerous, and more conspicuous on account of the spacing of the fascicles of spines. In the small specimen (in which the skeletal net has smaller meshes than in *P. biserialis*) the papulae per area range from 1 to 5, but in the large specimen there are commonly 8–12.

The madreporite is very large, with an irregularly lobed contour; extreme diameters 17 and 19 mm.

Sladen gives good figures of the actinal surface and description of the actinal armature. He could not determine, without mutilating the type and only specimen, how many spines belong to the adambulacral plates. I have made preparations of portions of the actinal surface of both Falkland specimens. The "behaviour" of the plates is highly peculiar.

SMALL SPECIMEN. The lateral-most series of fascicles (each with 3 spines) represents the superomarginals. Between each superomarginal fascicle and the furrow is a transverse series of 5 slender acicular spines encased in a thick sheath as shown in Sladen's fig. 7, pl. 73. The sixth or outer "spine" in his figure is really the *superomarginal fascicle*. The next spine toward furrow is the single inferomarginal, and the other 4 are adambulacral. A sodium hypochlorite preparation cleared in glycerin shows that the superomarginal plate, which is roughly oval in shape, is ankylosed to the dorsal and distal face of the outer third of the adambulacral plate. Owing to difference of refraction the two plates are easily identified. The inferomarginal can even be separated from the adambulacral but at this stage ankylosis has actually taken place. The lobed superomarginals overlap the inferomarginal ossicle.

LARGE SPECIMEN. Ankylosis of inferomarginal and adambulacral is complete. At the outer end of the adambulacral, the inferomarginal portion bends slightly distad. The angle is more marked on the dorsal aspect. On this side, the faint outline of the inner portion of the inferomarginal can sometimes be discerned overlying the outer half of the adambulacral, on its distal side, as in the small specimen. On the proximal two-thirds of ray the superomarginals (with 3–5 spines), are widely separated from the inferomarginals, the integument being devoid of any connecting skeletal elements. In middle of ray this zone is 5 mm. wide.

The adambulacral plates carry 1 or 2 short acicular furrow spines, and then a transverse series of 5 slender acicular subambulacrals graduated in length from the inner

(5.5 mm.) to the outer (6.5 mm.). The stouter inferomarginal (7 mm.) is spaced from the outermost subambulacral about twice the distance between the 2 outer subambulacra. All these spines are encased in a rather voluminous sheath which extends as a sacculus beyond the tip, making of the actinal armature a crowded confusion of long pulpy papillae.

The mouth-plates have a broad actinostomial border, and are deeply excavated on the furrow margin to accommodate the first tube foot. On the actinostomial border are three prominent spines; the inner is long, flattened, heavy; the next two are smaller, and the outer of these stands on a prominent angle of the margin. Near it, on furrow margin, is a fourth subequal spine, and then a fifth nearly as large as the apical spine. A suboral stands just back of the apical spine but is not so robust. There is considerable variation in the size of all these spines.

Tube-feet are large, and crowded roughly (as to tips) in 4 series. They remind one of *Diplopteraster*.

There is an extensive, complete, membranous interbrachial septum attached on all sides except that adjacent to eversible stomach. This free inner edge is about even with border of actinostome. The interrarial extent of the septum is about 40 mm.; the dorsoventral, doubtless quite variable, is 15 mm.

The voluminous gonads are attached at the junction of the interrarial septum with the abactinal wall, from the interrarial angle, at ambitus, nearly to the inner free edge of septum, or along about 30 mm. They open by several pores into an unspecialized interrarial sulcus. The outermost gonopore is fair sized and is at the ambitus. Two or three others can be detected when the integument is stretched under clear alcohol.

These two Falkland specimens differ from Sladen's type in having stouter rays and longer abactinal spines, and may represent a definite forma. But there are such marked differences between the two specimens that it is unwise to draw any conclusions until more material is available, the more so since the range of variation of the type form may be extensive. Sladen described and figured a unique specimen.

The specimen from off Marion Island measures R 64 mm., r 22 mm. (actual, not to end of spines), br 30 mm. (to end of spines). There are 1 or 2 furrow spines and usually 4 subambulacra. It appears to be typical *folliculatus*.

I add here a diagnosis of *Peribolaster* emended slightly from that which I published in 1911 (p. 341).

Korethrasteridae having the abactinal surface paved with cruciform plates whose delicate lobes are connected by supplementary ossicles, forming a fairly regular network of large quadrangular meshes over the entire surface. On the centre of each primary abactinal plate is borne, on a small boss, a fascicle of delicate subequal spinelets enveloped in membranous sheaths united in the interior of the fascicle. One to numerous papulae in each mesh; no actinal papulae. No actinal intermediate plates, the adambulacral plates imbricating with and sometimes fusing with the inferomarginals. Superomarginal plates cruciform and bearing a fascicle of spinelets; inferomarginals with a single prominent acicular spine, which forms with the similar adambulacral spines a

transverse series of 4-6, spaced and sheathed separately in membrane. Mouth-plates fairly large, of the type of the Pterasteridae, and with a prominent median keel; a few marginal spines and a single or no suboral spine. Membranous interradiial septum; gonads opening dorsally; tube-feet in 2 or 4 rows with fleshy, button-like terminal disk, devoid of deposits. No pedicellariae.

TYPE LOCALITY OF *P. FOLLICULATUS*. Challenger St. 304, off the Peninsula of Tres Montes, Chile, $46^{\circ} 53' 15''$ S, $75^{\circ} 12'$ W, 45 fathoms, green mud.

DISTRIBUTION. Southern Chile, the Falkland Plateau, and off Marion Island, 81-133 m.

Peribolaster macleani Koehler

Peribolaster MacLeani Koehler, 1920, p. 161, pl. 31, figs. 2, 5; pl. 33, figs. 1 and 2; pl. 68, fig. 4. St. 1660. Ross Sea, $74^{\circ} 46.4'$ S, $178^{\circ} 23.4'$ E, 351 m., 1 specimen.

The type specimen measured R 24 mm., r 9.5 mm., whereas the Discovery specimen has R 9 mm., r 3 mm. As Koehler has indicated the species is nearer to *P. biserialis* Fisher of the north Pacific than to *P. folliculatus*. But the subambulacral and marginal spines are entirely different to those of *biserialis*, being more or less flattened, broader at tip than near base, and terminated by several unequal, sharp awns (Koehler, pl. 68, fig. 4, b, c).

TYPE LOCALITY. $66^{\circ} 32'$ S, $141^{\circ} 39'$ E, 151 fathoms.

DISTRIBUTION. Antarctica (Australian Quadrant) from Queen Mary Land east to Ross Sea (longitude 94° - 178° E) never far north of summer ice (latitude $64^{\circ} 32'$ - $74^{\circ} 46.4'$); 191-581 m.

Family PTERASTERIDAE Perrier, 1875

Genus *Pteraster* Müller & Troschel

Pteraster Müller & Troschel, 1842, p. 128.—Type *Asterias militaris* O. F. Müller (monotypic).

Retaster Perrier, *Nouv. Arch. Mus. Hist. Nat.*, 2^e ser., 1, 1878, p. 56.—Type *Pteraster capensis* Gray, by designation, Fisher, 1919, p. 460.

Hexaster Perrier, *Comptes rendus*, CXII, no. 21, 1 May 1891, p. 1227; *Mém. soc. zool. France*, IV, 1891, p. 267. Type *Hexaster obscurus* (monotypic).

Temnaster Verrill (subgenus), *Proc. U.S. Nat. Mus.*, XVII, 1894, p. 275; *Amer. J. Sci.*, XLIX, 1905, p. 202 (as genus). Type *Pteraster (Temnaster) hexactis* = *Pteraster obscurus* (Perrier).

Lophopteraster Verrill, *Amer. J. Sci.*, XLIX, 1895, p. 202. Type *Pteraster abyssorum* Verrill.

Pterasterides Verrill, *Amer. Naturalist*, XLIII, 1909, p. 547, footnote. Type *Pteraster aporus* Ludwig = *Pteraster militaris* (O. F. M.).

The genus *Pteraster* has now accumulated a considerable number of nominal species. Within this assemblage there appears to be at least three natural groups, or sections. These are hardly of generic importance, but as subgenera will be of distinct service. By allocating a new species to its particular group, the task of identification is simplified at the outset. Subgenera can also lessen the danger of contrasting a new form with irrelevant species, on the ground of geographical proximity. The literature of every large

genus has numerous instances of misleading comparisons. Such are, of course, unavoidable, but none the less harmful.

The key to the subdivision of *Pteraster* seems to lie in the marginal spines of the mouth-plates. In the subgenus *Pteraster* the spines of each plate form an independent web and are hence most nearly like the webs of the adambulacral plates of which the mouth-plates are a modification. A majority of species have the actinolateral membrane narrow, a condition which may be regarded as less specialized than that in which the actinolateral spines reach or even pass the margin.

In *Retaster* the union of the oral spines goes a step further. A web is present between the apical spines, so that all the spines of a mouth angle are co-ordinated into a single webbed series—not two series as in *Pteraster*. In this group, species with a narrow actinolateral membrane are slightly more numerous than those with a medium or broad membrane.

In *Apterodon* the marginal mouth spines are not webbed at all. Sometimes a short abortive web unites the bases of two spines but this is in the nature of an individual variation. In this group the actinolateral membrane averages wider than in the two preceding subgenera.

The keys to the species of *Pteraster* which Clark (1908) and I (1911) published served their purpose but are now no longer reliable. Both Clark and I allowed too little latitude of variation in the number of adambulacral spines. In the following partitioning of species among three subgenera no attempt has been made to construct a key. What is needed now is a critical comparison of specimens, which are not available.

Subgenus *Pteraster* s.s. (including *Pterasterides*)

Pteraster, in which the series of marginal spines of each oral plate is independently webbed.

A. With abundant or sparse calcareous deposits in supradorsal membrane:

Pteraster militaris, type species. Bering Sea, Arctic Ocean, North Atlantic.

Pteraster lebruni Perrier. Falkland and Magellanic region, and neighbouring Antarctic.

Pteraster lebruni brachiatus Koehler. Kerguelen region; Marion Island.

Pteraster rugatus Sladen. Between Kerguelen and Heard Islands.

Pteraster trigonodon Fisher. Southern California.

Pteraster marsippus Fisher. Bering Sea.

B. Deposits of supradorsal membrane absent, or not reported:

Pteraster jordani Fisher. Pacific Coast of North America (Washington to Lower California).

Pteraster affinis Smith. Kerguelen; South Africa.

Pteraster aculeatus Koehler. Davis Sea (65° S, 96° E). Possibly the same as, or a race of, *affinis*.

Pteraster flabellifer Mortensen. South Africa.

Pteraster personatus Sladen. South-east of Ireland.

Pteraster reductus Koehler, off Azores.

Pteraster sordidus Perrier. Off Morocco.

Pteraster alveolatus Perrier. Near Azores.

Subgenus *Retaster* Perrier (including *Hexaster*, *Temnaster*)

Pteraster, in which the oral web is continuous across the point of the jaw so that all the marginal spines of an oral angle are united by one continuous membrane. Occasionally the small, outermost, spine may be free, or partly so.

- Pteraster capensis* Gray, type species by designation (Fisher, 1919, p. 460). South Africa.
Pteraster gibber (Sladen). Magellanic region.
Pteraster tessellatus Ives. West coast of North America from Strait of Fuca to Bering Sea.
Pteraster tessellatus arcuatus Fisher. Monterey Bay, California.
Pteraster pulvillus Sars. North Atlantic, Arctic Ocean, Bering Sea.
Pteraster multiporus Clark. Japan.
Pteraster corynetes Fisher. Molucca Passage.
Pteraster temnochiton Fisher. Aleutian Islands.
Pteraster obscurus (Perrier). Arctic Ocean, North Atlantic, Bering Sea.

Subgenus *Apterodon* nov.

Pteraster, in which the marginal mouth spines are not united by a web.

- Pteraster stellifer* Sladen, type species. Antarctic, circumpolar, north to Falkland Plateau.
Pteraster danae Verrill. Atlantic Ocean off coast of South America. Perhaps this and *stellifer* are races of the same species.
Pteraster coscinopeplus Fisher. California.
Pteraster reticulatus Fisher. Hawaiian Islands.
Pteraster fornicatus Mortensen. South Africa.
Pteraster obesus Clark. Japan.
Pteraster obesus myonotus Fisher. Philippine Islands.
Pteraster tetracanthus Clark. Victoria, Australia.
Pteraster carribaeus Perrier. Lesser Antilles.

The use of *Retaster* for a subgenus of *Pteraster* is necessitated by the fact that I made *capensis* the type species because Perrier placed it first, and since his description of Gray's *capensis* indicates a typical *Retaster* in the old sense. Several years later Clark (1923) and Mortensen (1933) found that *capensis* is not congeneric with *cribrosus* nor *insignis*. See below, under *Pteraster gibber*.

Pteraster florifer Koehler, 64° 34' S, 127° 18' E, 1700 fathoms, is not included in any of the above lists since the damaged type specimen lacks mouth-plates. I surmise that the species will ultimately fall in *Pteraster* s.s.

Pteraster ingouffi Perrier, in my opinion, is a synonym of *Diplopteraster verrucosus*; *Pteraster hunteri* Koehler, a synonym of *stellifer* Sladen, which may possibly later be merged with *danae* Verrill. *Pt. multispinus* Clark and *Pt. gracilis* Clark are probably synonyms of *Pt. tessellatus* along with *Pt. hebes* Verrill. *Pt. aporus* Ludwig is a synonym of *Pt. militaris*. *Pt. obscurus* includes *Pt. hexactis* and *Pt. octaster* Verrill.

Subgenus *Pteraster**Pteraster lebruni* Perrier

Pteraster lebruni Perrier, 1891, p. 144, pl. 13, figs. 4a-4b.—Ludwig, 1903, p. 29, pl. 3, figs. 25-28.—

Clark, 1908, p. 286 (key).—Fisher, 1911, p. 369 (key).—Koehler, 1917, pp. 49-52.—1920, p. 170.

St. 148. Off Cape Saunders, South Georgia, 132-148 m., grey mud, stones, 1 specimen.

St. 1958. 61° 17' 9" S, 52° 50' 8" W, 740 m., 1 specimen.

St. WS 81. 8 miles north-west of North Island, West Falkland Islands, 81-82 m., sand, 5 specimens.

St. WS 84. 7½ miles south-west of Sea Lion Island, East Falkland Island, 75-74 m., coarse sand, shells, stones, 1 specimen.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shells, 2 specimens.

St. WS 93. West Falkland Island, 51° 51' S, 61° 30' W, 133-130 m., grey sand, 3 specimens.

St. WS 97. North of Falkland Islands, 49° 00' 30" S, 61° 58' W, 146-145 m., 1 specimen.

St. WS 210. Falkland Islands, 50° 17' S, 60° 06' W, 161 m., green sand, 1 specimen.

St. WS 243. North-east of Falkland Islands, 51° 06' S, 64° 30' W, 144-141 m., coarse dark sand, 2 specimens.

St. WS 782A. North of Falkland Islands, 50° 29¼' S, 58° 23¾' W, 141-146 m., 1 specimen.

St. WS 831. 50° 50' 30" S, 66° 10' 30" W, 98-102 m., 3 specimens.

St. WS 871. 53° 16' S, 64° 12' W, 336-341 m., 7 specimens.

The largest specimen has R 72 mm., r 30-32 mm., R=2.25 r, br 35-36 mm. (St. WS 782).

This species so closely resembles *Pt. militaris* in general habit that the figures of the latter species published by me in 1911 would serve almost equally well for *lebruni*. The observation applies especially to the actinal surface. The width of the actinolateral membrane and the manner in which the adambulacral web extends beyond the outer spine of its comb across the actinolateral membrane is characteristic of both species.

The appearance of the supradorsal membrane is variable, as in all species of *Pteraster*, due, in part, to accidents of preservation, crowding in containers, etc. In some specimens it appears thick and folded, with no spinelets visible, as in my figure of *Pt. militaris* (Fisher, 1911, pl. 98, fig. 1). In the largest specimen, and a number of others (e.g. St. WS 81), the supradorsal membrane is not well hardened so that the ends of numerous spines protrude, very much as in my figure of *Pt. marsippus* and *Pt. jordani* (Fisher, 1911, pl. 100). The supradorsal membrane is crowded with deposits which have been figured by Ludwig. The abactinal paxillae have a low pedicel and usually three much longer spinelets, of which one is commonly stouter than the other two.

The adambulacral combs of large specimens have as many as 7 or 8 spines, and the mouth-plates 6-8 marginal spines, of which the two or three innermost are much longer than the others. The series of each plate is independently webbed. The first adambulacral webs of a mouth angle are not continuous across the interradius.

The suboral spines are variable in size and shape, but are always much thicker than the innermost marginal spine. Although usually subcircular in section almost to the tip, the terminal fourth or fifth may be triangular in section. In some specimens (e.g. Sts. WS 81, WS 871), however, this triangular condition extends throughout the distal

hyaline portion of the spine (about half total length). Less often (Sts. 148, WS 81) the three sides are concave in the middle region of the spine, greatly accentuating the three-edged condition (Fisher, 1911, pl. 116, fig. 3*b*, *Pt. temnochiton*). The edges are rounded, rather than sharp. Rarely a fusiform suboral spine has a flattened tip terminating in 3 or 4 small, sharp, points.

The tube-feet of the proximal half of ray are more crowded than in the strictly biserial arrangement, but it is probably an exaggeration to call them quadriserial. In the largest specimen the crowding continues to end of ray. The same condition exists in *militaris*, and is still more accentuated in *marsippus* and *jordani* (Fisher, 1911, pls. 98, 101).

The specimen from St. 148, South Georgia, measures R 37 mm., r 14 mm., $R=2.57r$. The adambulacral combs contain usually 5 or 6 spines. Marginal mouth spines 4-6; suboral spine, rather more slender than usual, 3-edged throughout the distal hyaline half, and the facets of the spine concave. Normally, of course, the spine is heavily sheathed, except the triangular point. It is questionable whether even this protrudes in life. The general habit is in no wise fundamentally different from the Falkland Plateau specimens.

The range of variation in the number of adambulacral and oral spines is in line with that of other species where the series of specimens is large enough to yield pertinent information. The variation in the shape of the suboral spine is somewhat disconcerting since the extremes have been used in differentiating species. In this series of *Pt. lebruni* we probably have indicated two formae, but there is far too little material to reach any conclusion.

This series indicates that *Pt. lebruni* is much more closely related to *Pt. militaris* than either Clark (1908) or I (1911) supposed when we compiled our "keys" to the species of *Pteraster*. For instance, we distinguished *militaris* from *lebruni* on the difference in the number of adambulacral spines which proves to be insignificant. Also I state that the suboral spine is not three-edged, whereas it sometimes is. No harm is done by this since the contrasted species, *trigonodon*, has long paxilla stalks carrying 6 spines.

Species of the southern hemisphere which are related to *lebruni* are:

brachiatus Koehler, 1917, p. 49, pl. 7, figs. 1, 2, 6; pl. 10, fig. 6. Kerguelen, 2 specimens. This seems to be a race of *lebruni*.

aculeatus Koehler, 1920, p. 168, pl. 38, figs. 3, 4, 5; pl. 65, fig. 6. 65° 06' S, 96° 13' E, 325 fathoms, 1 young specimen probably close to, or the same as, *Pt. affinis* Smith.

rugatus Sladen, 1889, p. 473, pl. 74, figs. 3, 4; pl. 77, figs. 3, 4. Between Kerguelen and Heard Islands, 150 fathoms.

marplatensis Bernasconi, 1937, p. 169, figs. 1, 2; pl. 1, figs. 1-4; pl. 2, figs. 3, 4. Argentina, 39° S, 57° 10' W, 45-97 fathoms. Also four other localities between 37° 40' and 38° 25' S, at 56° 30' W, 48-55 fathoms.

argentinus Bernasconi 1937, p. 173, fig. 3; pl. 2, figs. 1, 2. Argentina, 39° 26' S, 56° 25' W, 55 fathoms.

Pt. marplatensis Bernasconi is very closely related to *lebruni* and seems to me to be at best a race of that species. Bernasconi states that it differs from *lebruni* in the greater number of oral and adambulacral spines. But this number (7 or 8) is not greater than I find in large specimens of *lebruni*.

Pt. argentinus Bernasconi is also closely related to *lebruni*. It has the characteristic short paxillar pedicels and 3 (or 4) spinelets, one of which is longer than the others. Adambulacral and oral spines 6, the suboral long, tapered, slightly curved. The three known specimens have 6 rays.

The type and only specimen of *rugatus* is obviously young, measuring R 9.5 mm., r 6.5 mm. The form is pentagonal, paxillar spinelets 5-6; adambulacral spinelets 3 or 4; oral spines 3, webbed, the two webs of a mouth angle separated; suboral, longer than the other oral spines, "exceedingly thick, translucent triangular". Supradorsal membrane "indurated with minute spicules averaging 0.03-0.04 mm. in length, small, irregular, and angularly branching bodies, subdendriform in appearance and fairly well spaced".

A specimen of *lebruni* measuring R 9 mm. and r 5 mm. is distinctly stellate with angular interbrachia; paxillae with usually 3 spinelets; adambulacral spines 5 proximally; oral spines usually 5; suboral spine terminally triangular; actinolateral membrane proximally much narrower than in *rugatus* and, unlike that of *rugatus*, it narrows very gradually toward tip of ray.

Pt. affinis Smith, Kerguelen (possibly including *aculeatus* Koehler), has 5-10 paxillar spinelets, 4 adambulacral spines, 4 oral and a tricarinate (triangular) suboral. Both *affinis* and *aculeatus* appear to have a thin supradorsal membrane, without spicules.

TYPE LOCALITY OF *PTERASTER LEBRUNI*. Magellan region: "Washington Canal", 80 m.

DISTRIBUTION. Magellan and Falkland Plateau, to South Georgia on the east and Bellingshausen Sea on the south-west (71° 24' S, 89° 12' W); 74-450 m.

Pteraster lebruni brachiatus Koehler

Pteraster brachiatus Koehler, 1917, p. 49, pl. 7, figs. 1, 2, 6; pl. 10, figs. 6-10.

St. 1562. Off Marion Island, 46° 52' S, 37° 55' E. 97-104 m., 7 specimens.

St. 1563. Off Marion Island, 46° 48.4' S, 37° 49.2' E, 101-106 m., 3 specimens.

The largest specimen (St. 1562) measures R 48 mm., r 15 mm., br 18 mm., height of ray at base, 15 mm. The rays are narrower than in typical *lebruni*. The supradorsal membrane is thick, rugose, and crowded with deposits. In this specimen the osculum is as small as the diameter of a fine sewing needle, but in other specimens is well defined though small. It is probable that the osculum nearly or quite disappears in some specimens, as evidently happened in the case of a specimen of *Pt. militaris* from Bering Sea which Ludwig named *Pt. aporus* and which later Verrill designated as the type of *Pterasterides*.

The pedicel of paxillae is appreciably slenderer than in typical *lebruni* and there are ordinarily 3 or 4 slender paxillar spines of which one is slightly the heavier. Near the osculum there are sometimes 5.

What the photographs do not show clearly is that adambulacral combs have proximally 7 spines and distally 6. As in *lebruni* the web is continued across the actinolateral membrane as a series of parallel folds. In each of the 2 marginal fans of each oral angle are 8 spines while the suboral is heavy, clavate, with a sharp, prismatic hyaline tip. Small

examples (e.g. R 13 mm.) have usually 5 ambulacral and 5 oral spines and the same number of paxillar spines as the adult.

It is probable that these specimens are not typical *brachiatus*, but are near to that race and emphasize its close similarity to *lebruni*. Koehler states that the paxillae of his type “ne comprennent guère qu’une demi-douzaine de piquants divergents, dont l’un, plus développé, soulève la tente dorsale et la perce pour faire saillie au dehors”. “Scarcely half a dozen” is not greatly different from 3 to 5, while the puncturing of the supradorsal membrane is not a normal condition, but an accident either of handling or preservation.

One stomach contained some remains of branching bryozoans and miscellaneous organic debris.

TYPE LOCALITY. Kerguelen.

Subgenus *Retaster*

Pteraster gibber (Sladen)

Retaster gibber Sladen, 1889, p. 481, pl. 74, figs. 5 and 6; pl. 77, figs. 7 and 8.—Ludwig, 1905, p. 65, pl. 6, figs. 6 and 7.—Bernasconi, 1937, p. 185.

St. WS 248. Falkland Islands, 52° 40' S, 58° 30' W, 210–242 m., fine green sand, pebbles, shells, 1 specimen.

The specimen is smaller than Sladen's type, with broader rays, so that the contour is subpentagonal. R 20 mm., r 12 mm. $\pm$, $R = 1.6 r$. The abactinal surface is arched, the body being thick and cushion-like. The supradorsal membrane shows the characteristic quadrate and pentagonal reticulum figured by Sladen. The actinolateral membrane is very narrow. The adambulacral combs contain 6 spines instead of the 5 figured by Sladen. The innermost or furrow spinelet is small and the fan here curves distad. Each oral plate carries a marginal series of 8 spines (the outermost 4 being small). The 16 are united in a single web. Sladen states that the type carries 3 oral spines per plate. This is a big discrepancy even for variable *Pteraster*. It seems likely that the outer spinelets were overlooked, as Ludwig (1905, p. 66) has indicated. Ludwig's larger specimen carried 6 oral spines (R 18 mm.).

The largest paxillae, supporting the interr radial lateral portion of the supradorsal membrane, consist of an elongate pedicel and 7–9 peripheral spinelets meeting the supradorsal membrane on the periphery of the areoles. There is a central group of 3 or 4 spinelets, slenderer and more acute than the peripheral, the tips of which are usually slightly clavate and thorny.

Pt. gibber is closely related to *Pt. tessellatus* Ives¹ and *Pt. capensis* (Perrier).² The first ranges from Bering Sea to Washington; the second is from the Cape region of Africa.

Clark remarks on the close resemblance of *Pt. capensis* and *Pt. tessellatus*, stating that the only constant difference between the two species “seems to be in the structure of the paxilla: in *capensis* each paxilla has a single central spinelet of a size about equal to the surrounding series of 6 or 7 similar spinelets, while in *tessellatus* instead of this central

¹ Fisher, 1911, p. 359, pl. 104, figs. 1–5.

² Clark, 1923, p. 299, pl. 9, figs. 3 and 4. Mortensen, 1933, p. 267, pl. 14, figs. 1–3; text-fig. 9.

spinelet is a cluster of smaller and more slender spinelets". If this character is constant in *capensis*, then *gibber*, with a small tuft of slender central spinelets, is more like *tesselatus*. In full-grown specimens of *tesselatus* there are 7 or 8 stout peripheral spines and upward of 18 much more delicate ones in a central group.

The colour of the 3 is much the same—dark or pale violet: *capensis* sometimes has a dark angular ring on the upper surface on a paler ground colour. *Tesselatus* is usually mottled with fawn colour, but may also have darker markings. *Gibber* seems to have been dark violet grey in life.

The figure of the oral plates of *capensis* (Mortensen, *loc. cit.*, text-fig. 8) would serve almost as well for *gibber*. In our specimen the suboral spines are slightly longer and heavier, but circular in section (as in *capensis*). Ludwig's specimen of *gibber* had 6 marginal spines. In *capensis* the number (*fide* Clark) varies from 5 to 7.

GENERIC POSITION OF *PTERASTER GIBBER*. The close similarity of *gibber* to *tesselatus* and *capensis*, which are regarded as *Pteraster*, naturally excludes it from *Retaster*. Clark (1923, p. 298) has restricted *Retaster* to *cribrosus* von Martens and *insignis* Sladen. He designated *cribrosus* as the type species, under the impression that this formality had never been complied with. When Perrier instituted the genus¹ he listed *Pteraster capensis* and *Pt. cribrosus* without fixing either as type. Sladen² was the first to give the group a standing but neglected also to designate a type. In 1919³ the present writer chose Perrier's first species, *Pteraster capensis*, for the type of *Retaster*. At that time, this seemed to be a perfectly safe procedure since Perrier (1875, p. 382) had seen the type of Gray's *capensis* and stated: "Par la structure de leur tégument dorsal, soutenu par un réseau à large mailles formées de ligaments unissant les épines qui le soutiennent, et par leur grande taille, ces deux espèces (*capensis* and *cribrosus*) s'éloignent des autres *Pteraster*, et peut-être faudra-t-il créer pour elles un genre spécial.

"Un échantillon unique desséché au British Museum.—Du cap de Bonne-Espérance."

Unfortunately, since *Retaster* has been formally attached to *Pteraster capensis* Gray it becomes, for the time being at least, a synonym of *Pteraster* in its widest sense.

The genus heretofore known as *Retaster* may appropriately be called *Euretaster*, type *Retaster insignis* Sladen. Included species: the type and *Pteraster cribrosus* von Martens. The reasons for choosing *insignis* for the type are: there is a definite, well-preserved type specimen from Challenger St. 189,⁴ Arafura Sea, 25 fathoms; Sladen's illustrations are excellent and detailed. Since *Pt. cribrosus* has been designated (though erroneously) the genotype of *Retaster*, it seems inadvisable to employ it again as the genotype of *Euretaster*.

TYPE LOCALITY OF *PTERASTER GIBBER*. Challenger St. 311, off entrance to Smyth Channel, 52° 45' 30" S, 73° 46' W, 245 fathoms, blue mud, bottom temperature 46° F.

DISTRIBUTION OF *PTERASTER GIBBER*. Strait of Magellan and appropriate depths on both coasts; 27–500 m., blue mud, fine sand, pebbles, shells.

¹ *Nouv. arch. Mus. Hist. Nat.* 2^e ser., 1878, 1, p. 56.

² Sladen, 1889, p. 477.

⁴ Designated as type locality, Fisher, 1919, p. 461.

³ Fisher, 1919, p. 460.

Subgenus *Apterodon*

Pteraster stellifer Sladen

Pteraster stellifer Sladen, *J. Linn. Soc. Lond. (Zool.)*, xvi, p. 193.—1889, p. 474, pl. 74, figs. 1, 2; pl. 77, figs. 1, 2.—Bernasconi, 1937, p. 176.

Pteraster hunteri Koehler, 1920, p. 165, pl. 37, figs. 4–10; pl. 38, fig. 8; pl. 75, fig. 8.—1923, p. 81.—Bernasconi, 1937, p. 176.

St. 175. Bransfield Strait, South Shetlands, 200 m., 1 specimen.

St. 652. Burdwood Bank, 169–171 m., 2 specimens.

St. WS 81. 8 miles north-west of North Island, West Falkland Islands, 81–82 m., sand, 3 specimens.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shells, 5 specimens.

St. WS 88. Falkland Islands, 54° S, 64° 57' 30" W, 96–127 m., shell and stones, 1 specimen.

St. WS 216. Falkland Plateau, 47° 37' S, 60° 50' W, 219–133 m., fine sand, 2 specimens.

St. WS 224. Falkland Plateau, 50° 18' S, 65° 07' W, 124–126 m., 1 specimen.

St. WS 228. Falkland Plateau, 50° 50' S, 56° 58' W, 229–236 m., 23 young.

St. WS 231. Falkland Plateau, 50° 10' S, 58° 42' W, 167–159 m., fine green sand, 2 young.

St. WS 237. Falkland Plateau, 46° S, 60° 05' W, 150–256 m., coarse brown sand and shells, 48 young.

St. WS 243. North-east of Falkland Islands, 51° 06' S, 64° 30' W, 144–141 m., coarse dark sand, 1 young.

St. WS 246. Falkland Islands, 52° 25' S, 61° W, 267–208 m., coarse green sand and pebbles, 1 young.

St. WS 248. Falkland Islands, 52° 40' S, 58° 30' W, 210–242 m., fine green sand, pebbles, shells, 1 specimen.

St. WS 781. Falkland Islands, 50° 30' S, 58° 50' W, 148 m., 1 specimen.

St. WS 795. East of Cape Tres Puntas, 46° 14' S, 60° 24' W, 157–161 m., 1 specimen.

St. WS 800. 48° 15' 45" S, 62° 09' 52" W, 137–139 m., 1 specimen.

St. WS 824. Falkland Islands, 52° 29½' S, 58° 27¼' W, 146–137 m., 13 specimens.

St. WS 831. 50° 50' 30" S, 66° 10' 30" W, 98–102 m., 2 young.

St. WS 871. 53° 16' S, 64° 12' W, 336–341 m., 2 young.

The largest specimen (St. WS 85) measures R 23 mm., r 13 mm., and is therefore smaller than the type, in which these dimensions are respectively 34 and 23 mm. Sladen's figures show the general habit satisfactorily, although in this series of specimens the stellate protuberances of the supradorsal membrane are seldom so prominent as shown by Sladen, and are masked altogether in a very considerable proportion of the specimens. The condition pictured by Sladen is approached closely by the series from St. WS 824. Here the 6–8 peripheral paxillar spines radiate more or less symmetrically from the pedicel top, and there is usually a single central spine. A feature characteristic of most specimens is the conspicuous lateral fringe of actinolateral spines, and the deeply emarginated web of their membrane. While in some specimens this from above defines the entire ambitus, in others from the same station it is visible only on outer part of ray. It is not indicated in Sladen's pl. 74, fig. 1.

The figures of the actinal surface given by Sladen are good, although the form of the adambulacral comb must not be interpreted too literally as it varies even in the same specimen. If the membrane is greatly contracted the adambulacral spines seem to

protrude above the border of a deeply emarginated web. The slightly emarginated web figured by Sladen (pl. 77, fig. 2) is not characteristic of the species, although I find an exactly similar condition on the proximal part of the rays of a specimen from St. WS 216; but on the distal part the spines protrude much more than in Sladen's figure. The continuous web of the first pair of adambulacrals over the outer end of oral plates is well shown by Sladen in pl. 74, fig. 2. The adambulacral spines, stated by Sladen to be 5, are frequently 6.

Each oral plate has 5 or 6 marginal spines entirely without connecting web. The suboral spine is slender, tapered, sharp, and normally entirely encased in membrane. It is very similar to the innermost marginal spine. This latter in some instances moves outward upon the actinal surface of the plate so that there are then 2 suboral spines (St. WS 85). These two form with the second marginal spine (now somewhat enlarged) a curved interradiial series and give to the mouth angle a very abnormal appearance, since the suboral spines are also more robust than in typical specimens.

A number of specimens are carrying young which can be seen in the nidamental cavity through the supradorsal membrane. In one of these which measures R 12 mm., the young are very small with 2 pairs of podia and a ventral yolk sac. Already a supradorsal membrane, showing a large central osculum, has developed (St. WS 824, 19 January 1932). In another specimen, R 11 mm., the young, about 2.25 mm. in diameter and irregularly circular, have 4 pairs of podia and a large terminal "tentacle". The actinolateral web is very prominent, extending as a pair of webs or fans on either side well beyond the end of the radius. The remains of the yolk sack is a convex mass on the mouth. The adambulacral and oral spines are differentiated but too delicate to count accurately, St. 652.

Pt. hunteri is rather typical *Pt. stellifer*. Koehler adduces as the principal difference (the spine counts being the same) the fact that paxillar spinelets of *hunteri* do not have the symmetrical posture shown by Sladen's figure. This is rather a naïve viewpoint for a veteran worker! Sladen obviously describes and figures a specimen, not a species. Scarcely any structure in the entire gamut of sea star morphology is more liable to modification by preservatives, or subsequent crowding, or maceration, than the supradorsal membrane of *Pteraster*. A specimen from St. WS 85 exhibits the stellate posture of the paxillar spinelets on two rays, but elsewhere on the abactinal surface (to quote Koehler) "la disposition régulière des pignants des paxilles est complètement différente". Koehler (1920, pl. 37, figs. 4-10) gives excellent photographic figures of the variations of the abactinal surface. Fig. 9 shows well the ambital fringe of actinolateral spines and web mentioned above. Furthermore, Koehler (1923) records his *hunteri* from east of the Falklands.

TYPE LOCALITY. Challenger St. 311. Off entrance to Smyth Channel, 52° 45' 30" N, 73° 46' W, 245 fathoms, blue mud, bottom temperature 46° F.

DISTRIBUTION. Magellanic and Falkland region to South Shetland Islands, 79-500 m.; south Indian Ocean, 64° to 66° S, 96° to 140° S, 110-358 fathoms. Circumpolar, and probably divisible into local forms.

Genus *Diplopteraster* Verrill*Diplopteraster verrucosus* (Sladen)

Retaster verrucosus Sladen, *J. Linn. Soc. Lond. (Zool.)*, xvi, 1882, p. 196.—1889, p. 478, pl. 76, figs. 1, 2; pl. 77, figs. 9, 10.—Koehler, 1908, p. 550.

Pteraster Ingouffi Perrier, 1891, p. 144, pl. 12, figs. 4a, 4b.—Bernasconi, 1937, p. 176.

Pteraster ingolfi (error typ.) Fisher, 1911, p. 370 (key).—1919, p. 458.

Diplopteraster verrucosus Fisher, 1911, p. 370.—Koehler, 1923, p. 76, pl. 11, fig. 5; pl. 12, fig. 1.—Bernasconi, 1939, p. 183, pl. 7, fig. 2; pl. 8, fig. 2.

Diplopteraster Nordenskjöldi Koehler, 1923, p. 77, pl. 10, figs. 4–8.—Bernasconi, 1937, p. 184, pl. 7, fig. 1; pl. 8, fig. 1.

The Roman numerals V–VIII indicate number of rays; e.g. 29 V, 1 VI = 29 five-rayed and 1 six-rayed.

St. WS 81. 8 miles north-west of North Island, West Falkland Island, 81–82 m., sand, specimens 29 V, 1 VI.

St. WS 84. $7\frac{1}{2}$ miles south-west of Sea Lion Island, East Falkland Island, 75–74 m., coarse sand, shells, stones, specimens 5 V.

St. WS 85. Falkland Islands, $52^{\circ} 09' S$, $58^{\circ} 14' W$, 79 m., sand and shells, specimens 6 V.

St. WS 90. 13 miles north-east of Cape Virgins Light, Argentina, 82–81 m., fine dark sand, specimens 1 VI.

St. WS 91. Tierra del Fuego, $52^{\circ} 53' 45'' S$, $64^{\circ} 37' 30'' W$, 191–205 m., fine dark sand, shell, specimens 2 VI.

St. WS 92. Between Falkland Island and Straits of Magellan entrance, $51^{\circ} 58' 30'' S$, $65^{\circ} 01' W$, 143–145 m., specimens 5 VI.

St. WS 93. South-west of Beaver Island, West Falkland Island, 135–130 m., specimens 1 V, 1 VI.

St. WS 109. Falkland Islands, $50^{\circ} 18' 48'' S$, $58^{\circ} 28' 30'' W$, 145 m., fine dark sand, specimens 1 V.

St. WS 210. Falkland Islands, $50^{\circ} 17' S$, $60^{\circ} 06' W$, 161 m., green sand, specimens 2 V.

St. WS 243. North-east of Falkland Islands, $51^{\circ} 06' S$, $64^{\circ} 30' W$, 144–141 m., coarse dark sand, specimens 6 VI, 1 VII, 1 VIII.

St. 776. Off Cape Tres Puntas, Argentina, 107–99 m., specimen 1 V.

St. 781. Falkland Plateau, $50^{\circ} 31' S$, $58^{\circ} 50' W$, 148 m., specimen 1 V.

St. 782A. Falkland Plateau, $50^{\circ} 29\frac{1}{4}' S$, $58^{\circ} 23\frac{3}{4}' W$, 141–146 m., specimen 2 V.

St. WS 784. $49^{\circ} 47' S$, $61^{\circ} 05' W$, 170 m., dark green sand, specimen 1 V.

St. WS 813. $51^{\circ} 35\frac{1}{4}' S$, $67^{\circ} 16\frac{1}{4}' W$, 106–92 m., specimen 2 VI.

St. WS 816. $52^{\circ} 09\frac{3}{4}' S$, $64^{\circ} 56' W$, 150–160 m., specimen 1 VI.

The largest 5-rayed specimen (St. WS 782) measures: R 76 mm., r 51 mm. The abactinal aspect agrees with Sladen's figure. The actinolateral membrane is somewhat broader. The apparent width of the actinolateral membrane is modified by the posture of the adambulacral combs, and to a slight degree by retraction during preservation. In this large specimen there are usually 5 spines in both sorts of adambulacral combs; but in the less prominent comb 1 or 2 spines next to furrow are small. The number of spines per comb starting with the first plate run as follows, an asterisk marking the alternate, smaller plate: 5, 5*, 5, 5*, 5, 5*, 5, 4*, 5, 4*, 4, 5*, 6, 5*, 5, 5*, 5, etc. There are usually 5 marginal spines to each oral plate or 10 to a mouth angle, completely webbed. This number is not invariable, for one plate may have 4 spines, the other 5; or, as in the largest example, 5 and 6. The suboral spine, relatively slender and completely sheathed in

membrane, equals or slightly exceeds in length the longest marginal spine. Sometimes a short accessory suboral is present on outer half of plate.

The largest specimen having more than 5 rays (6-rayed) measures: R 56 mm., r 38 mm. The 7-rayed example measures: R 35 mm., r 21 mm. The 8-rayed example measures: R 40 mm., r 29 mm. In all respects other than number of rays these specimens are typical *verrucosus*. The differences which Koehler believed sufficient to justify a new species, *nordenskjöldi*, are either not constant or else not characteristic. For instance, the difference in the appearance of the abactinal surface (Koehler, 1923, p. 80) is merely a difference such as may exist between two 5-rayed specimens, as well as between a 5-rayed and 6-rayed. Sladen's figure of the abactinal surface of the type of *verrucosus* indicates the areolated, or honey-combed, condition which is even more accentuated in some of the 5- and 6-rayed examples before me. The supradorsal membrane in such specimens is sunken within the circle of props formed by $10 \pm$ peripheral paxillar spines; while the longer, heavier central spine of the paxilla forms a characteristic eminence in the middle of each areole (Sladen, pl. 77, fig. 9). Sometimes, due to a variety of causes (such as crowding in container), the supradorsal membrane does not exhibit this areolated appearance. There appears to be no essential difference between the 5-rayed and 6- to 8-rayed examples in the adambulacral and oral armature nor in the size of the tube-feet.

Fortunately, a 5-rayed specimen having R 50 mm. (St. WS 85, 25 March 1927) was found to be carrying young in the supradorsal space. These occupied chiefly the lateral portions of the interradii, but smaller young were found in one ray two-thirds the distance to tip. The number of young in each interradius was as follows: A, 1 with 4 rays, 3 with 5 rays; B, 2 with 5 rays, 2 with 6 rays; C, 4 with 5 rays, 2 with 6 rays; D, 2 with 5 rays, 2 with 6 rays, 1 with 5 mouth angles but 6 rays; E, 5 with 5 rays, 1 with 6 rays. Total: 25, of which 16 had 5 rays, 8 had 6 rays and 1 had 4 rays. It is therefore obvious that the 6-rayed condition is much more fundamental than in *multipes* where it is very rare.

The largest of these 25 young has 5 rays and measures R 9 mm., r 6 mm. The first adambulacral comb contains 4 spines; the next, 5, the innermost being very small; then 3 plates with 4 spines; then one with 5, innermost very small; then 3 plates with 4 spines, etc. The oral angle has a fan of 8 completely webbed spines. The crowding of the tube-feet is already very apparent but the adambulacral plates have not yet become differentiated into two sorts. The actinolateral membrane is about as broad as in the adult. There are about 8 peripheral paxillar spinelets and 1 central. The osculum is as well developed as in the adult.

A 6-rayed young, with R 5 mm., found in the same interradius, has essentially the same spine counts.

The smallest of the 25 has 6 rays with R 3.5 mm. It was found together with a 5-rayed young rather far along the ray. Adambulacral combs contain mostly 4 spinelets each.

In a 6-rayed specimen (St. WS 243, 17 July 1928), having R 38 mm., nine 6-rayed young and one 5-rayed were found. Two 6-rayed young, with R 6.5 and 7.5 mm. were about

ready to leave the marsupium, but the other eight were quite small, R ranging from 1.25 to 2.5 mm. The smallest (6-rayed) specimen has 3 adambulacral spinelets and 3 oral spinelets per plate. The actinolateral membrane, with 5 spines on either side of each ray, extends conspicuously beyond the border and tip of the ray proper as in *Hymenaster*. The terminal papilla of radial water tube is large and there are 6 pairs of tube-feet to each ray.

From this glimpse into the genetics of the species it is evident that the 6-rayed specimens are not specifically distinct. It is significant that the majority of the young of a 5-rayed parent are 5-rayed; and of a 6-rayed parent preponderantly 6-rayed. It is probable that the 7- and 8-rayed specimens are from 6-rayed rather than from 5-rayed parents (or from 7- and 8-rayed parents).

Pteraster obscurus of the north Atlantic, Arctic Ocean and Bering Sea has 6-9 rays. In a large 7-rayed specimen I found two 6-rayed young,¹ and in two adults with 8 rays I found one 9-rayed, three 8-rayed and two 7-rayed young—all three sorts occurring in the same parent. *Pteraster obscurus*, although aberrant for the genus, seems to be much nearer to *Pteraster* than to *Diplopteraster*.

Perrier's figures of *Pteraster ingouffi*, although small, indicate clearly the general habit and crowded tube-feet of *Diplopteraster verrucosus*. With a lens one can distinguish the two sorts of adambulacral combs. *Ingouffi* is described as having a slender suboral spine encased in membrane and a fan of 10 oral spines completely webbed. This describes *verrucosus* exactly, as no other *Pteraster* of the region has this oral armature. *Pt. gibber* has the marginal spines united by membrane but the suboral is heavy not slender, and the actinolateral membrane is characteristically narrow—entirely unlike that of *ingouffi*.

TYPE LOCALITY. Challenger St. 313. Near the Atlantic entrance to the Strait of Magellan, 55 fathoms, sand; bottom temperature, 47.8° F.

DISTRIBUTION. Falkland Plateau, north to latitude 40°, coast of Argentina; south to Navarin Island (Perrier) and Burdwood Bank (Koehler); 74-270 m.

Diplopteraster semireticulatus (Sladen)

Pteraster semireticulatus Sladen, *J. Linn. Soc. Lond. (Zool.)*, xvi, 1882, p. 195; 1889, p. 475, pl. 75, figs. 5, 6; pl. 77, figs. 5, 6.

St. 1562. Off Marion Island, 46° 52' S, 37° 55' E, 99-104 m., 3 specimens.

The smallest and only perfect specimen measures R 13 mm., r 8 mm., and is therefore for all purposes the same size as the type, the figures of which it closely resembles. This specimen has 4 or 5 adambulacral spines in irregular alternation, the innermost of the series (and sometimes the second in the case of 5 spines) being conspicuously shorter than the others. The supradorsal membrane is semi-transparent. The paxillae have 6 or 7 rather long delicate spinelets surrounding a central one, essentially as in the type specimen (Sladen, pl. 77, fig. 5). The tube-feet are crowded, incipiently quadriserial, but

¹ Fisher, 1911, p. 365, pl. 105, fig. 1.

the adambulacral combs have not yet become differentiated whereby alternate fans project farther into the furrow. Except for a rather wider actinolateral membrane this specimen resembles an equal-sized young of *D. verrucosus* (St. WS 210) which likewise lacks any marked differentiation of alternate adambulacral combs and has only incipiently quadriserial tube-feet.

Unfortunately the adult specimen, as well as a medium sized one, is incomplete through maceration. The size before softening was probably close to R 45 mm., r 22 mm. The supradorsal membrane is thick and verrucose as in *D. verrucosus*. Near the centre of disk the paxillae have 8-10 long slender peripheral divaricate spinelets and an obviously stouter central one surmounting a slightly longer slender pedicel, which is longer in interradii than on radial area; on outer half of ray the pedicels rapidly shorten and there are commonly 8 peripheral spines.

Along the only complete series of adambulacral plates the spine counts run as follows: mouth-plates 5, first adambulacral 4, then 5, 5, 4*, 5, 4*, 5, 4*, 4, 4*, 4, 4*, 4, 4*, etc. The "recessive" series are marked *. When the prominent series has 4 spines, the furrow member is nearly as long as the second spine, while in the recessive series it is usually less than half as long. The suboral spine is long and slender, close to the innermost marginal oral spine to which it is united by a web (not present in the other 2 specimens). The web of the first adambulacral series is continued across interradius uniting with the other first series, behind mouth-plates. The two second series nearly meet.

It should be noted that Sladen's type of *reticulatus* was immature, that it already showed a reticulate dorsal membrane and crowded tube-feet. The differentiation of the adambulacral combs is not at all obvious in *D. verrucosus* until R is 20 mm. It is not apparent in specimens as small as the type of *D. reticulatus*.

This species is closely related to *verrucosus* and *multipes*. *D. perigrinator* (Sladen) from off Kerguelen has furrow combs of 7 or 8 spines alternating with combs of 5. But it will not be surprising if the three ultimately prove to be forms of one species.

TYPE LOCALITY. Off Marion Island, 69 fathoms, volcanic sand.

Family BRISINGIDAE G. O. Sars

Genus *Odinella* nov.

DIAGNOSIS. Related to *Odinia* but differing in having a more specialized genital region confined to first 4 skeletal arches, the intervals between which are without plates on sides of ray; first intercostal area laterally modified in female to form part of a specialized axillary brood chamber; sacculi of lateral and some of abactinal spines of ray extremely thick, ovoid to subglobular in form. Papulae appearing late, not numerous, confined to disk and genital region; pedicellariae very small, confined to sacculi and absent from abactinal area of disk; gonads 2 to each ray, opening laterally in first intercostal space; interradiial plate (odontophore) hidden by abactinal integument of interbrachial angle; first post-oral adambulacral of each mouth angle closely apposed to its fellow, and above them a pair of small closely joined inferomarginal plates (Fig. H, 1);

ray breaks at muscular joint between first and second adambulacrals (no adambulacral syzygial joints). Type, *O. nutrix*.

REMARKS. This genus differs from all known Brisingidae in having in each inter-radius a highly specialized, axial, brood chamber, in which young are protected until they attain a diameter of at least 6 mm. The number of rays, 11-14, is determined at the outset of development and is not increased by later additions, as in *Labidiaster*.

Odinella may be regarded as an off-shoot of *Odinia* stock with which it agrees in the possession of papulae on both disk and rays, a single subambulacral spine, and probably in the general structure of the actinostomial ring. In *Odinella* there is no completely syzygial joint among the proximal adambulacral plates such as is found in *Brisinga*, *Craterobrisinga*, *Brisingella*, and *Astrostephane*, *inter alia*. It is probable that no complete syzygy occurs in *Odinia*, notwithstanding my statement to the contrary.¹ Doubt is cast on the matter by a ray of *Odinia magister* apparently broken from the disk between first and second adambulacrals. There are remnants of muscle on the proximal face of what I take to be the second adambulacral. The succeeding joints are muscular ones except possibly the upper part of the second-to-third. I do not have adequate material to examine this question in other species of *Odinia*.

No known Brisingid has a genital region as concentrated as that of *Odinella*. On this basal inflation of the ray are numerous dorsolateral spines, some of which grow fast to the opposite body wall, locking together, in gravid males and females, all the genital regions into a sort of circular accessory disk, bristling with spines longer than those of the disk proper. As a special adaptation this contrivance undoubtedly prevents loss of rays which have at best a flimsy attachment to the disk. In the female these spine-bridges, as well as the numerous interdigitating but free spines, form a basket work which effectively confines the eggs and developing young to the brood chambers, into which fresh water is driven by cilia. The functional part of the arm for locomotion and trapping of crustacea (by means of the pedicellariae) is restricted to the flexible region distal to the genital inflation.

In *Odinia*, the sides of the proximal part of ray between the skeletal arches is provided with numerous stout plates in a close irregular mesh. The arches are rather poorly defined near disk. Very numerous papulae occur on the sides as well as dorsal surface of the genital inflation, which extends along ray, for 9 or 10 well-spaced arches and reaches its greatest size at about its middle, not anywhere close to disk. In *O. magister* the male gonad opens near base of ray (as in *Odinella*) either in the first or second intercostal area which are here heavily plated and difficult to distinguish from the primary arches.

Brisingaster de Loriol, which strongly suggests *Odinia* except that the intercostal plates are embryonic and there are no papulae, differs from both *Odinella* and *Odinia* also in having gonads in a series of 8 or 9 proximally just above the adambulacral plates. There appears to be a syzygy between first and second adambulacral plates. Throughout the genital area of 9 or 10 well-spaced complete arches, the subambulacral spine has a modified expanded truncate tip. First pair of adambulacral plates (and sometimes most

¹ Fisher, 1919, p. 501: 1928, p. 4.

of second pair) united interradially; directly above them is the united pair of first inferomarginals, conspicuously larger than in *Odinella*, their inner ends broadly engaging the lower outer end of interradiial plate, which is much more conspicuous superficially than in *Odinella*.

STRUCTURE OF ACTINOSTOMIAL RING (Fig. H). The relative size and position of the plates of the ventral skeleton of the disk, known as the actinostomial ring, is usually super-specific. To a certain extent their form is also characteristic of genera rather than species, especially in the case of the mouth-plates.

The actinostomial ring consists of two concentric circles of plates intimately joined. Each radial sector of the inner circle consists of the first pair of ambulacral plates locked between a single mouth-plate on either side (Fig. H, 6, 7). The odontophore, called the interradiial plate, forms a keystone above the mouth-plates, which are further bound together by muscles (Fig. H, 6, *o'*, *o''*). The outer circle consists, radially, of the second pair of ambulacrals, and a pair of first adambulacrals; interradially, of a pair of inferomarginals whose size and position is of considerable importance (Fig. H, 1, 6, 8, *m*). Also of importance is whether the joint between the first and second adambulacrals is a muscular or a non-muscular symphysis (syzygy).

The structure of the actinostomial ring may not be ignored if the affiliations of a species, new or old, are to be determined. The *Brisinga* of Asbjörnsen, G. O. Sars, Sladen, and Ludwig was not homogeneous. The relations of the plates of the ring gave the clue to a subdivision into more natural generic groups. The same is true of *Freyella*.¹

In Fig. H is recorded the structure of the actinostomial plates of *Odinella* and for comparison, those of *Brisingella*. This comparison must be worked out in connection with the explanation of the figures, as a description would be of doubtful value. Attention may be called to certain significant points. In the interbrachial angle, the relation of the first adambulacrals and first inferomarginals, *inter se*, presents almost the extremes of contrast in *Odinella* and *Brisingella*. Of a type similar to that of *Odinella* is the arrangement in *Odinia*, *Brisingenes*, *Brisingaster*, *Brisinga*, *Craterobrisinga*, *Astrostephane*. Irrespective of details of difference in the ring plates these genera can be separated as follows:

- a*¹. Papulae on disk and rays; no true syzygy between first and second adambulacrals; gonads 2 to each ray.
 - b*¹. Genital area elongate with stout intercostal plates on side of rays; no brood pouch. *Odinia*.
 - b*². Genital inflation very short, without intercostal plates on sides of rays; specialized brood pouch. *Odinella*.
- a*². Papulae on disk only; a syzygy between first and second adambulacral plates; gonads in series on each side of ray. *Brisingenes*.
- a*³. No papulae; a syzygy between first and second adambulacral plates.
 - b*¹. Gonads 2 to each ray.
 - c*¹. Integument between costae without plates. *Astrostephane*.
 - c*². Integument between plates crowded with spineless plates. *Stegnobrisinga*.

¹ Fisher, *Ann. Mag. Nat. Hist.*, ser 8, xx, 1917, p. 418; also, 1919, p. 502; 1928, p. 4.

- b*². Gonads numerous, in series on either side of base of ray.
- c*¹. Disk plates small, bearing one to several small spinelets; on the ray only one lateral or marginal spine (never a comb of several); no intercostal embryonic plates; furrow spine or spines present.
- d*¹. Proximal subambulacral spine or spinus acicular; second subambulacral when present at adoral end of plate; adambulacral armature not dense and crowded. *Brisinga*.
- d*². Proximal subambulacral spines with modified, capitate, often truncate tip; a second, prominent subambulacral regularly present near aboral end of plate, armature crowded. *Craterobrisinga*.
- c*². Disk plates large, with 1-3 fairly large acicular spines; a vertical series of 4 conspicuous lateral spines to each successive skeletal arch of ray; integument between costae with spaced embryonic plates; no furrow spinelets; 1 prominent subambulacral with modified capitate tip throughout genital region. *Brisingaster*.

A comparison of Figs. 2 and 3, 5 and 7, indicates a considerable difference in the form of mouth-plate. In descriptions of species only the exposed oral face of the plate is considered, whereas the dorsal and lateral extensions which are intimately concerned in the structure of the ring are really of greater importance. With modifications of the mouth-plates are linked changes in the first ambulacra.

The odontophore exhibits considerable individuality.

Even in genera, having the general arrangement of first adambulacra and marginals indicated above, the marginals differ in size and posture and the distal joint of the adambulacral may be muscular or non-muscular.

The development of muscles between adjacent mouth-plates (Fig. H, 6, *o'*, *o''*) varies in different genera.

Odinella nutrix sp. nov.

(Figs. G, 1-6; H, 1-9; Plates XIV, XV, XVI, figs. 1-11; Plate XVII, figs. 1-3)

DIAGNOSIS. Rays 11-14, usually 12 or 13. R 75-80 mm., r 7 mm. (type). Rays abruptly swollen at base into a specialized genital region with numerous irregularly placed abactinal spines, which dorsolaterally and laterally interlock with those of adjacent rays and sometimes form permanent bridges, protecting, in axils of female, a specialized brood chamber; beyond genital area, ray narrow, very flexible, with a series of lateral, slender, spaced costae bearing 3 or 2 acicular spines immersed in ovoid sacculi covered with pedicellariae; 1 subambulacral spine with lateral succulus; 1 suboral and 2-4 marginal oral spines; disk small, sunken below level of the rays, the spinelets devoid of pedicellariae; papulae on disk and genital region only; pedicellariae very small, the oral different in form from those of rays. A 12-rayed specimen (St. 123) measures R 100 mm., r 7 mm.; br, at disk, 2-3.5 mm.; at middle of genital inflation 5-13 mm.; at middle of R 3.5 mm.

DESCRIPTION. The general appearance, well shown by the figures of entire specimens, is highly characteristic and very different from that of any known *Brisingid*. In mature specimens the genital region of the ray is inflated, irregularly spiny and papulose, in close contact with adjacent rays, and slightly longer than width of disk. The distal

portion is abruptly narrower than the genital, and devoid of plating except for the regular lateral, spaced costae, which, except for the first 1 or 2 beyond the genital region, do not reach entirely across the ray but simply support the thin integument as props extending upward from, usually, each fourth adambulacral. These lateral "ribs" carry a vertical series of 3 acicular long spines enveloped in an ovoid fleshy sacculus covered with minute pedicellariae. These thick sacculi are found also on some of the abactinal spines of the genital region, and possibly in living specimens are still more numerous but have been lost by abrasion in the dredge.

The disk is dorsally convex, the convexity accentuated by the dorso-ventrally constricted ray at its opening into disk (Pl. XVI, fig. 4). Its abactinal wall is reinforced by irregularly roundish or short-lobed, slightly imbricating plates 0.5–1 mm. in diameter and carrying 1, 2, or 3 skin-covered spinelets, subacicular or variously pronged. Some examples are given in accompanying figures. Apparently the disk spinelets never carry the clavate sacculus. Scattered large papulae are more numerous in a marginal zone than at centre of disk. Pronged spinelets are more numerous in immature specimens than in fully adult; that is, later additional spinelets are more likely to be of the acicular type.

The abactinal skeleton of the genital region, like that of disk, is normally obscured by the skin and is more open, with very irregular elements. A study of growth stages does not indicate that the abactinal plates of the genital region, in excess of those of the simple arches, represent ancestral arches partly suppressed. On the abactinal surface between arches II–III, and III–IV the extra plates have, in medium-sized specimens, an easily discernible transverse alignment (Pl. XVI, fig. 3). On the proximal part of the genital region the larger plates have 2 or 3 lobes and carry 1–3 sharp acicular spines while the oblong connectives which join them and achieve thus a very irregular reticulum carry usually a shorter one. On the sides of this region the arches of plates are arranged, with slight variations as in Pl. XVI, fig. 3, which represents a medium-sized male with gonopore in the middle of the large intercostal space I. This area of thin skin becomes, in the female, one side of the nidamental cavity (Pl. XVII, fig. 1). This area is always bounded proximally by arch I, the lower end of which is formed by inferomarginal 2 resting on adambulacrals 2 and 3. Inferomarginal 1 and adambulacral 1 remain on the disk when a ray is detached. When the nidamental cavity is functioning, arch II is not so straight as shown in Pl. XVI, fig. 3, but is strongly bowed or bent distally. The oviduct opens at about mid-height on its proximal border. Arches III and IV extend completely across the ray from side to side; but arch V is represented on either side by a "rib" of 3 or 4 plates, each bearing a spine. From arch V or VI onwards, each rib of plates consists of an inferomarginal, a superomarginal, and a dorsolateral plate, each carrying a long spine covered by a fleshy sacculus (Pl. XVI, figs. 1, 2). Toward end of ray there may be only 2 lateral plates and spines. In the type there are 4 complete arches plus 19 pairs of lateral ribs.

Small isolated radial plates occur sporadically along the radial line and carry groups of pedicellariae sometimes without a central spinelet.

The terminal plate, though small, is modified to protect the relatively large terminal

sense organ (Pl. XVI, figs. 6–8). It is deeply hollowed on the actinal face, and the border of the distal half carries, on either side, 6–8 acicular spines which support a fleshy cushion of tissue (coalesced sacculi) thickly beset with pedicellariae. In the young, this compound sacculus appears very early and its pedicellariae are the first to be developed, indicating the importance of the terminal sense organ (Pl. XVI, figs. 9–11). The form and relative size of the sense organ are indicated in the figures.

In fully developed specimens papulae occur on the disk, as indicated above; on the dorsal surface of the genital region, irregularly according to the skeletal meshes, dwindling to 1 or 2 dorsally in intercostal spaces VI or VII; on the *lower* part of intercostal spaces I to VI where, in the type, space I has 2 or 3; II and III have 5 or 6 each; IV has 2 (but numerous ones on dorsolateral region); V has 1; VI has 1 or 0. In the medium-sized specimen figured (Pl. XVI, fig. 3) only the first 3 spaces have papulae in this position. The dorsal and dorsolateral papulae are omitted to avoid confusion of lines. Apparently the papulae never encroach upon the upper part of the intercostal space I. In a specimen (St. 123) having R 18 mm. (Pl. XVII, fig. 2) I can find no papulae. In a specimen with R 37 mm. (St. 172) papulae have appeared sparingly in a marginal zone on disk, dorsally on the short, developing genital region, and ventrolaterally in intercostal spaces I and II (1 papula to each) (see also Growth stages, 4).

Intercostal space I, in the female, becomes the side of the nidamental cavity and, with the growth of the young, is forced inward to the sagittal plane until it presses against the similarly stretched wall of the other side of ray. The hepatic coeca occupy the arched upper portion of the swollen genital region and their connection with the stomach is through the very constricted opening of the base of ray (Pl. XVI, fig. 4). The already small aperture afforded by the first skeletal arch is further decreased by a membranous diaphragm in the dorsal part of the first arch, as indicated in the figure. In fully grown specimens this diaphragm is even more extensive than in the figure and the passage to ray is correspondingly smaller.

The general facies of actinal surface is well shown by the photograph. The adambulacral plates, short at base of ray and gradually becoming longer and lower as is characteristic of Brisingids, bear each a single acicular spine on the actinal surface. This spine is similar and subequal to the lateral spines at base of ray, but soon the latter are decidedly the longer. It carries a lateral flap of tissue covered with pedicellariae and the tip of the proximal spines is not in the least degree modified. No furrow spinelets present. The first adambulacral plate remains on the disk when a ray breaks off. The joint between the first and second plates is a muscular one, not different from the preceding nor the third and following ones, except that the muscular space widens slightly as the flexible portion of ray is reached. At each mouth angle the first pair of adambulacral plates is tightly apposed by the lateral face, and the second pair to a less extent, that part which is involved being indicated by dots in Pl. XVII, fig. 5. Above the first united pair of adambulacrals is a pair of small inferomarginals forming a part of the disk skeleton; while above adambulacrals 2 and 3 is inferomarginal 2 (Pl. XVI, fig. 5), a portion of the lateral face of which (dotted) is joined to its fellow of the adjacent ray.

The superficial portion of the mouth-plates slopes downward from the outer end to the broad actinostomial margin, which is close to peristomial membrane and carries 6-8 skin-covered spines to each pair of plates. The median, longest, of the fan are about as long as the median suture and slightly shorter than the pair of suboral spines, which stand on the distal margin and are in all respects like the first adambulacral spines. The median marginal spines carry a few to a conspicuous tuft of pedicellariae; the laterals have a few or none. These lateral members of each comb overlap those of the adjacent "jaws" and close the narrow entrance to the ambulacral furrow.

The madreporite is on the extreme margin of disk and difficult to find in large alcoholic specimens owing to crowding of the swollen genital region of ray. In young specimens it has a single groove (interradial in direction) and resembles a miniature "bivalve". This groove next becomes sinuous (R 47 mm.).

PEDICELLARIAE. The pedicellariae are all very small. Those which thickly cover the surface of the sacculi measure, in adults, 0.115-0.14 mm., measured on the long axis of the figures (Fig. G, 5-5*b*). The first to be developed are on the terminal sacculus of ray (stage 2 under "Development"); next (stage 4) they appear on the primary radial plate and a very few on the adambulacral spines. The first of the lateral sacculi of the ray probably do not develop until after the young leave the brood chamber. All these pedicellariae are essentially similar in shape and size. When the animal is practically adult the larger and differently formed pedicellariae of the marginal mouth spines appear on slight flanges of tissue. These measure 0.16-0.185 mm. high. The base of each blade or jaw is greatly developed and flares outward as may be appreciated from the figures (Fig G, 6*a*, 6*b*). The middle piece (*mp*) is very large, while the excessively fine teeth of centre of jaw are much more numerous than in the common type of pedicellaria. It is probable that the oral pedicellariae, appearing as they do rather late, will be more valuable as a generic character than the other type, which resemble, in a general way, the small pedicellariae of *Odinia*, *Brisingaster*, and even those of the distantly related *Brisingella* and *Freyellaster*.

GONADS. The gonads when ripe are voluminous and form two clusters to each ray, almost filling the genital chamber at its base. The ovary opens on distal margin of the first intercostal area at about mid-height of the second skeletal arch; while the male gonopore is in the centre of the area.

NIDAMENTAL CAVITY. In each interradius or axilla, so that the interradial angle (with its 2 first skeletal arches) forms part of its walls, is the cavity where eggs are deposited and develop. The very concave intercostal area 1 forms either side wall; while interdigitating spines of arches II and III and of the dorsal plates, above area 1, constitute a sort of basket work, with small passages through which water can circulate. The manner in which these dorsolateral spines interlock is evident from the photographs, but what is not clearly shown is that some of the spines form a continuous organic bridge between adjacent rays. These sharp spines, either by their growth or by the expansion of the body wall deeply pierce the integument of the opposite ray, and the sheath of the spine coalesces with the skin of the opposite ray. When the rays are forced apart the

spine sheath ruptures leaving the spine-tip bare and part of the sheath attached to the opposite body wall.

As the 5-9 eggs of each "basket" develop, the first intercostal membrane becomes more and more concave. The young usually have their ventral surface against the sides of this basin-like hollow, but not invariably. There are usually 2 or 3 which are developed much further than the rest. Those shown in the enlarged photograph are probably nearly ready to escape. Beneath such young, crowded against the pouch wall, there may be several very immature ones, or even eggs.

In a sample brood chamber of the large 13-armed specimen, St. 123, were 8 young in 2 stages: (1) three in the youngest stage as described below, rays 12, 13, 14; (2) five with 13 rays in stage 4. The next pouch, B, has 2 eggs; three young in the first stage (one with 11 rays, two with 13 rays); three (with 13 rays) in stage 4. Pouch C, same specimen, had a cluster of 6 eggs and three 13-rayed young in stage 1.

This is the first instance of brooding reported for the Brisingidae and is noteworthy for the position of the nursery as well as for the details of adaptation. *Especially extraordinary are the permanent spine bridges across the dorsal side of the chamber.*

DEVELOPMENTAL STAGES. The eggs found in brood pouches are subspherical, sometimes slightly flattened on one side, 1.5 mm. in diameter. One ellipsoid 2 mm. by 1.4 mm. was found.

Stage 1. In the earliest stage encountered (Fig. G, 4) the total diameter is 2.5 mm. The disk is low hemispherical and the rays from above are scarcely more than buds 0.3-0.4 mm. long. The disk is beset with widely spaced spine buds. The circle of the actinostome occupies most of the actinal surface. The nerve, terminal organ, and 3 or sometimes 4 pairs of tube-feet have appeared, and swellings of the end of ray on either side of the terminal tentacle indicate the first terminal spinelets. The oral angle is sketched in but there are no calcareous plates. Distance from oral angle to tip of ray, 0.65-0.75 mm. A specimen prepared in sodium hypochlorite has the beginnings of the following plates: abactinal of disk (4*b-d*); 4 pairs of ambulacrals, 2 of adambulacrals (no spinelets); terminal (2 spinelets). All these are in a very embryonic state. There is no trace of pedicellariae.

Stage 2 (Pl. XVI, fig. 9). Diameter about 3.5 mm. The chief advance is the appearance of numerous pedicellariae on the conspicuous sheath in which the 4 or 5 terminal spinelets are immersed. The rays are relatively longer to the still strongly convex disk; disk spinelets longer; tiny mouth pore; 2 adambulacral spines; rudimental mouth-plates; 4 pairs of tube-feet. Distance from actinostome to end of ray, 1 mm. (1 example from type).

Stage 3. Diameter 4.25 mm. Rays slightly longer, but no abactinal spinelets; disk strongly convex with subcircular embryonic plates, their spinelets slightly longer than in 2; terminal ruff of pedicellariae larger; 6 terminal spinelets, 4 pairs of tube-feet with rudiments of fifth pair on some rays, the proximal 3 pairs relatively slightly larger than in 2, and with strong sucking disks; 3 adambulacral spinelets on each side of furrow; the rudiment of a lateral oral spine to each mouth-plate (as in stage 2, Pl. XVI, fig. 9) but

definitely no suboral spine; hepatic diverticula visible through transparent peristome. Distance from mouth-plates to end of ray, 1.25 mm.

Stage 4. Diameter 5 mm.; diameter of peristome 1.7 mm.; distance from mouth-plates to end of ray 1.6–1.7 mm. The disk is now only slightly convex; the disk plates are subcircular (Fig. G, 3) and as well marked as in stage 5; the spinelets (3 *a-b*) end in 3 or 4 short thorns. On the rays the rudiments of the first arch have appeared: 3 dorsal plates, the median or radial with a spinelet and a circle of 6–10 pedicellariae; the laterals (superomarginals) with the bud of a spine; next to the adambulacrals on either side is the rudiment of an inferomarginal plate. The 3 adambulacral spinelets are now much more conspicuous and may carry several pedicellariae. The mouth-plates are larger, with a short suboral spine, and the second shorter marginal spine adjacent to median suture. The terminal ruff of pedicellariae is still larger and there are 8 slender conspicuous terminal spines. The outline of the stomach and hepatic diverticula is clear through the transparent peristome but the mouth and lips seem to be covered by tissue.

Stage 5 (Pl. XVI, figs. 10, 11). Diameter 6–6.2 mm.; diameter of peristome, 2.5 mm.; distance from mouth-plates to tip of ray, 1.85 mm. This differs from the last chiefly in increase in size. The rays are slightly longer and there are 6 pairs of tube-feet and 4 prominent adambulacral spines, but no additional oral spines nor abactinal ray spines, and no spine on the rudimentary inferomarginal plate. This is the stage shown in photographs, and it seems probable that the young soon leave the nursery through the ventral side of the brood "basket".

GROWTH STAGES. (1) The youngest post-nursery stage is a 12-rayed specimen from St. 123 having the following dimensions: diameter 14 mm., R 6–7 mm., r 2.5 mm.

The disk is not convex and is paved with relatively large, roundish, thin, overlapping plates bearing each a 3-pronged spine. This plating ceases abruptly at base of ray, to be followed after a very narrow interval of skin by the first skeletal arch composed of 7 plates, of which the unpaired mid-dorsal is usually 3-lobed, larger than the others, and carries a prominent sacculated acicular spine; the other shorter spines without a sacculus. The second arch, well spaced from the first, has a tiny mid-dorsal spine and 3 conspicuous sacculated laterals. Then there are two widely spaced arches with 2 lateral sacculated spines, and rudimentary dorsal plates; and finally a rudimentary fifth arch near the conspicuous terminal sacculus.

The adambulacral and mouth spines are relative to length of ray much longer than in adult, and the former bear a lateral sacculus of pedicellariae. The second marginal mouth spine to be developed is now longer than the lateral. The first pair of adambulacrals only touch by their inner ends adjacent to oral plates, and the first and following interadambulacral joints show no sign of a syzygy. These proximal adambulacrals are more elongated than in the adult. This condition and the separation of the first pair of adambulacrals at oral angle is similar to the structure of *Brisingella*.

(2) The next larger specimen (St. 39) is somewhat mangled but two of the 13 rays can be measured: diameter 24 mm., R 11–12 mm. r 3.75 mm. There are now 7 skeletal arches. The first 3 are clearly complete. The fourth to sixth are technically completed by

a flat, embryonic midradial plate without a spinelet. These are probably the isolated radial plates of the adult that are usually out of alignment with the paired costae. The seventh arch near the terminal "complex" appears to have this radial plate. Irregularity of plates at base of ray (arches 1 and 2) is foreshadowed by the appearance of secondary plates and spinelets—the beginning of the differentiation of a genital region. The primary radial plate can be recognized. In the third to seventh arches the spines are so spaced as to give the appearance of a complete arch of spines of which there are 8 on the second to fourth arches and 6 on the fifth to seventh. Proximally, 3 spines on either side have a heavy sacculus, distally 2. Many of the mouth-plates have 3, but a few of them 2 marginal spines. In each mouth angle there has been a rapprochement of the first adambulacral plates which are now nearly as in the adult.

Some of the disk plates have an additional spinelet. The prongs of the spines are slightly longer than in the preceding stage.

(3) St. 123 (Pl. XVII, fig. 2); extreme diameter 34 mm.; R 13–17 mm., r 3.75 mm. The disk diameter of this well-preserved 13-rayed specimen is the same as that of the preceding, but the unequal rays are longer, comprising 10 or 11 skeletal arches which do not differ in character from those of the preceding specimen. The trilobate primary radial plate with its prominently sacculate, aciculate spine is conspicuous. A smaller dorso-lateral spine on either side usually has a smaller sacculus. The 3 or 2 lateral sacculi of succeeding arches are large. Two spinelets, 0.57 and 0.6 mm. long, from disk of this specimen, are figured (Fig. G, 1, 1a). Only one of the 26 mouth-plates has 3 spines; the other have 2.

(4) St. WS 42. Extreme diameter 60 mm.; R 23–37 mm., r 5 mm. The short rays may be regenerating the tips. Rays 13. The first appearance of papulae, there being about 10 on the disk, situated interradially near margin. One ray has a papula near the base. The genital region is swollen so that base of ray is convex and higher than plane of disk. The lateral aspect of ray is *similar* to Pl. XVI, fig. 3, but smaller, and no papulae are present adjacent to adambulacral plates. The base of rays are closely appressed and dorsolateral spinelets interdigitate, but no permanent spine bridges have been formed. There are 18 skeletal arches, complete and incomplete, and the dorsal aspect of ray is similar to adult. The sacculi are large and subglobose. Most of the lateral ribs have 3 spines and sacculi; sometimes on outer part of ray, only 2, as in the fully adult. Each mouth-plate has 4 or 3 marginal spines.

FOOD. Samples of stomach contents of specimens from Sts. 42 and 123 were submitted to Dr Isabella Gordon for determination.

St. 39. The exoskeletons of 4 Cumacea, probably *Gaussicuma* were found in the stomach of the type. (W. K. F.)

St. 42. Specimen A: remains of Cumacea and small Mysidae. (W. K. F.) Specimen B. "Cumacea of the family Bodotriidae (as used by Zimmer, 1927). Appear to be males of *Gaussicuma*, a genus hitherto known only from females." (Gordon.)

St. 123. Largest specimen (R 100 mm.), a few Cumacea. (W. K. F.)

Small specimen (Pl. XVII, fig. 2). When first removed from bottle a number of

small Mysidae were held fast by the pedicellariae. (Gordon.) Possibly these were caught while in the trawl. The stomach contained fragments of a cumacean and appendages of a mysid.

COLOUR NOTE. Specimen from St. 42: disk whitish cream, arm bases light pink criss-crossed with white calcareous network; arms (beyond genital area) whitish cream; sacculi orange.

TYPE LOCALITY. St. 39, East Cumberland Bay, South Georgia, 179–235 m., grey mud. 25 March 1926, 1 large, 1 medium sized, 1 small specimen.

SPECIMENS EXAMINED. In addition to three from type locality, the following:

St. 42. Off mouth of Cumberland Bay, South Georgia, 120–204 m., 1 April 1926, 2 specimens.

St. 123. Off mouth of Cumberland Bay, South Georgia, 230–250 m., grey mud, 15 December 1926, 2 adults, 2 immature.

St. 172. Off Deception Island, South Shetland Islands, 525 m., 26 February 1927, 1 immature specimen.

St. WS 42. South Georgia, $54^{\circ} 41' 45''$ S, $36^{\circ} 47'$ W, 198 m., mud, stones, 7 January 1926, 1 immature specimen.

St. WS 766. $44^{\circ} 58'$ S, $60^{\circ} 05'$ W, 545 m., 1 immature specimen in bad condition.

Family ASTERIIDAE Gray, emended

(See Fisher, 1928, p. 56 for synopsis of subfamilies.)

Subfamily PEDICELLASTERINAE Fisher

Pedicellasterinae Fisher, 1918, p. 108.—1923, p. 249.—1928, p. 57.

Genus *Pedicellaster* Sars

Pedicellaster Sars, *Översigt af Norges Echinodermmer*, Christiania, 1861, p. 77. Type *P. typicus* Sars.—Fisher, 1923, p. 251; 1928, p. 58 (revision).

Pedicellaster hypernotius Sladen

(Fig. F, 3)

Pedicellaster hypernotius Sladen, 1889, p. 558, pl. 105, figs. 5–7.

Pedicellaster antarcticus Ludwig, 1903, p. 35, pl. 4, figs. 32–38.—Koehler, 1920, pp. 106–109, pl. 16, fig. 11; pl. 17, figs. 8, 9.

St. 156. South Georgia, $53^{\circ} 51'$ S, $36^{\circ} 21' 30''$ W, 200–236 m., rock, 1 specimen.

St. 160. Near Shag Rocks, $53^{\circ} 43' 40''$ S, $43^{\circ} 57'$ W, 177 m., grey mud, stones and rock, 7 specimens.

St. 170. Off Cape Bowles, Clarence Island, $61^{\circ} 25' 30''$ S, $53^{\circ} 46'$ W, 342 m., rock, 2 specimens.

St. 181. Schollaert Channel, Palmer Archipelago, $64^{\circ} 20'$ S, $63^{\circ} 01'$ W, 160–335 m., mud, 2 specimens.

St. 190. Bismarck Strait, Palmer Archipelago, $64^{\circ} 56'$ S, $63^{\circ} 35'$ W, 93–130 m., rock or stones and mud, 2 specimens.

St. 1955. South Shetland Islands, $61^{\circ} 35' 1''$ S, $57^{\circ} 23' 3''$ W, 440–410 m., 1 specimen.

In the largest specimen, St. 156, $R=23.5$ mm., $r=3.5$ mm. It is sexually mature. In the type specimen, collected by the 'Challenger', off Marion Island, 140 fathoms,

R=25 mm., r=5 mm. The type of *P. antarcticus*, from Bellingshausen Sea, 450 m., measures R 30 mm., r 5 mm.

The principal difference between *antarcticus* and *hypernotius*, according to Ludwig, is the presence of 3 spinelets on each carinal plate of the former and only one in the latter species. In the Discovery specimens the number varies from 1 to 3, and occasionally to 4.

The larger of the two varieties of crossed pedicellariae is abundant on the sides of ray and distally they encroach upon the abactinal surface. They are very similar to those of *P. magister* Fisher¹ a relatively gigantic species from Bering Sea and the Alaskan coast, but are unlike the major crossed pedicellariae of *P. typicus* (Fisher, 1928, pl. 26, fig. 1). The jaw varies between 0.3 and 0.4 mm. in length. The minor pedicellariae are *circa* 0.22 mm. long. There are also pedicellariae intermediate in size and form between the major and minor varieties. Very small, blunt, triangular straight pedicellariae (0.15 mm. long) occur along the furrow margin, as figured by Sladen (1889, pl. 105, fig. 7). In the specimen from St. 1955, in which R is only 9 mm., the two sorts of crossed pedicellariae are well differentiated.

In these small specimens there is only 1 series of actinal plates. The extraordinary development of the actinal system of *P. magister* is not even suggested.

The only other Antarctic *Pedicellaster* is *formatus* Koehler (1920, p. 106, pl. 16, figs. 1, 9, 10; pl. 17, figs. 6, 7; pl. 58, fig. 4) from 120 fathoms, 66° 08' S, 94° 17' E. It differs chiefly in having stouter plates and may ultimately prove to be a form of *hypernotius*.

The Discovery specimens extend the known range of the species from Bellingshausen Sea along the Antarctic Archipelago to South Georgia and Shag Rocks.

Genus *Anteliaster* Fisher

Anteliaster Fisher, 1923, p. 252; 1928, p. 69. Type *A. coscinactis* Fisher.

Anteliaster australis sp. nov.

(Fig. I, 1-1d; Plate IX, figs. 2, 3)

DIAGNOSIS. Differing from *C. coscinactis* Fisher in lacking unguiculate straight pedicellariae and in having a relatively close-knit skeleton with usually only 1 papula to each area of disk and rays; spinelets short, close-set, interspersed with numerous crossed pedicellariae, attached to the plates, giving the body a uniform finely granulose appearance; to the touch the texture is like that of fine sand-paper. R 35 mm., r 5 mm., br 6 mm., R=7r.

DESCRIPTION. The body is covered with slender, short, thorny tipped spinelets, rather uniformly spaced about their own length; 1-3 spinelets to a plate. Everywhere between the spinelets are crossed pedicellariae, attached to surface of plates and also to membrane of papular areas. The spinelets, only slightly longer than the pedicellariae, combine with them to give the surface a rather uniform granular appearance.

¹ Fisher, 1928, p. 63, pl. 26, fig. 2; pl. 27, fig. 2.

Marginal plates lateral in position. Superomarginals with 3 spinelets, reduced to 2 and 1 at end of ray. Inferomarginals with 2 spinelets, reduced to 1 distally, before the reduction of superomarginal spinelets occurs. Actinals with 1 spinelet.

The skeleton is basically like that of *A. coscinactis* (Fisher, 1928, pl. 29, fig. 1) but the skeletal intervals relative to size of plates are much smaller; that is, the mesh is less open. If the specimen were larger (R 63 mm. in *coscinactis*) it is possible the difference would be less. The secondary ossicles uniting inferomarginals to actinals of *coscinactis* are lacking in *australis*, while the secondary intermarginal ossicles extend only a fourth the length of ray (in larger specimens, undoubtedly farther). The dorsolateral skeleton is irregular as in *coscinactis*, the plates 3- and 4-lobed, and the smaller papular areas are in about 3 irregular longiseries. There is one series of actinals extending far along ray and a short second series about one-third length of ray. The papular areas are distributed as in the figure of *coscinactis* but contain a single papula, except for a few intermarginal areas proximally which have 2.

In a smaller specimen (St. WS 86) most of the proximal dorsolaterals are 3-lobed and imbricate more regularly.

Adambulacral spines conspicuously longer than marginals and actinals, disposed in transverse series, 4 on first 3 or 4 plates, then 3. The outermost spine is clavate, the furrow spine terete and much more slender, while the middle one is intermediate. Each mouth-plate has 2 short spinelets on the inner border, extending over the peristome; and in line with the inner spinelet is a series of 3 successively longer ones on the surface of the narrow plates. On the distal furrow corner of plate is a spinelet conspicuously shorter and slenderer than outermost suboral. The first pair of adambulacrals behind mouth-plates is separated by a slight interval. The disposition of oral spines is closely similar to that of *A. coscinactis* (Fisher, 1928, pl. 29, fig. 1 b).

Madreporeic body small, with few coarse striae, situated near margin at top of inter-brachial sulcus.

There are no straight pedicellariae. The crossed closely resemble those of *A. coscinactis*, differing only in minor details. They vary in length from 0.18 to 0.4 mm., the greater number being 0.27–0.35 mm. in length. The largest are found on the actinal and inferomarginal plates where they are mixed with average sized; while the smallest are on the abactinal surface, there mixed with medium sized which are slightly smaller than the actinal average.

The gonads open in the interval between the inferomarginal and actinal plates, 3 or 4 mm. from the interbrachial angle. Each gonad consists of a cluster of relatively large branched tufts, the lobules being irregular in form and unequal in length. The inter-brachial septum is very rudimentary, practically non-existent, the coelom of disk being therefore undivided. This is an advantage to the animal which ingests its food entire. In the stomach of a specimen with disk diameter of 9 mm. were two gastropod shells, the larger a sharp cone 9 mm. long.

TYPE LOCALITY. St. WS 248, East Falkland Island, 52° 40' S, 58° 30' W, 210–242 m., fine green sand, pebbles, shells, 3 specimens.

SPECIMENS EXAMINED. Including the above, 11 specimens.

- St. 156. South Georgia, south-east of Larsen Point, 260 m., mud, 1 specimen.
 St. 160. Near Shag Rocks, 177 m., grey mud, stones and rock, 2 specimens.
 St. WS 81. North-west of North Island, West Falkland Island, 81–82 m., 1 specimen.
 St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 2 specimens.
 St. WS 825. North-east of East Island, Falkland Islands, 135–144 m., 1 specimen.
 St. WS 871. Falkland Islands, 53° 16' S, 64° 12' W, 336–341 m., 1 specimen.

REMARKS. At Sts. 156 and 160 *Pedicellaster hypernotius* was taken. There is considerable superficial resemblance between the two species.

If the identification of the specimens listed as *Anteliaster scaber* (Smith) is correct, *australis* is a very different species. The spinelets of *scaber* are longer and the crossed pedicellariae have a different form.

Anteliaster scaber (Smith)

(Fig. F, 4, 4a)

Pedicellaster scaber Smith, *Ann. Mag. Nat. Hist.*, ser. 4, xvii, p. 107; *Phil. Trans.*, Zoology, Kerguelen Island, CLXVIII, 1879, p. 274, pl. 16, fig. 3.

St. 1563. Off Marion Island, 46° 48.4' S, 37° 49.2' E, 101–106 m., 2 specimens.

St. 1564. Off Marion Island, 46° 36.5' S, 38° 02.3' E, 108–113 m., 2 specimens.

In the absence of type material for comparison the identification of these small specimens must be regarded as provisional. The largest measures R 10 mm., r 2.5 mm. Since they were taken so near to the type locality of *Pedicellaster hypernotius*, they have been examined with that species in mind. However, there are no straight pedicellariae on the furrow margin and the proximal adambulacrals, as well as numerous others here and there along the ray are triplacanthid. There is only one kind of crossed pedicellaria (0.2 mm. long). The species is therefore not a *Pedicellaster* but an *Anteliaster*.

In the largest specimen there is one series of actinal plates which extends half the length of ray; each plate with 1 small spinelet. The intermarginal papular areas are the largest. One inframarginal series of small areas extends as far as the actinal plates; dorsolateral areas small. Dorsal plates and spinelets not in definite longiseries. The actinal surface has the bristling appearance depicted by Smith's figure.

Subfamily LABIDIASTERINAE Verrill, emended

Labidiasterinae Verrill, 1914, p. 26.—Fisher, 1919, p. 492; 1928, p. 88.

Rays numerous (9–50), long, slender; inferomarginal spines prominent, single, enveloped in a sheath carrying on the usually expanded distal surface a conspicuous wreath of crossed pedicellariae; abactinal skeleton either very open with large squarish meshes or else abortive with scattered independent plates; crossed pedicellariae in abactinal spinal wreaths or thick ruffs; no actinal plates; gonads two to each ray, opening upon the side a short distance from base; tube-feet numerous, biserial to quadriserial, each with a single ampulla.

The subfamily as here understood is rather isolated and contains *Coronaster* Perrier, *Rathbunaster* Fisher (eastern north Pacific) and *Labidiaster* Lütken.

REMARKS. Verrill included only *Labidiaster* and the synonymous *Labidiastrella* in this subfamily, which he placed in the Brisingidae, following the usual treatment of *Labidiaster*.

Labidiaster differs from *Brisinga*, *Odinia*, *Freyella*, and similar Brisingids in the following important particulars: (1) its abactinal skeleton is not duplicated in the Brisingidae; (2) forficiform, or straight, pedicellariae are present; (3) the adambulacral plates are crowded, very short in proportion to width, and entirely unlike in form and armature the same highly peculiar plates of all Brisingidae; (4) the adambulacralia are shorter, especially the dorsal ends, which overlap, or imbricate with, the next adoral ambulacral plate, while in the Brisingidae there is no sign of imbrication, the ambulacralia resembling the centra of chordate vertebrae, with vertical articulating adoral and aboral facets.

In the Brisingidae (less *Labidiaster*) the abactinal skeleton of the rays is variable, being in the form of transverse, independent, parallel ridges or costae, separated by areas of integument without plates; or the intervals may be partially or completely filled in with more or less imperfectly developed plates immersed in the body wall; or the arches may be absent and a tessellation of thin plates may cover the genital region of the ray; or there may be thin plates, more or less spiniferous, together with differentiated transverse costae.

In *Labidiaster* the skeleton of the ray is closely similar to that of *Coronaster*. There is a longitudinal series of trilobate inferomarginal plates, one of quadrilobate or cruciform superomarginal plates, and one of cruciform median radial plates. The marginals and radials form regular transverse series. On the basal portion of the ray there is a more or less irregular zigzag series of trilobate dorsolateral plates. The primary plates either connect directly by their slender lobes, or these are joined by 1 or 2 overlapping, oblong, intermediate ossicles. There results an open, fairly regular, reticulate skeleton having large tetragonal meshes (except where the dorsolateral plates frame pentagonal openings). On the outer part of ray the longitudinally oriented, intermediate, connectives and similarly oriented lobes of marginals and radials gradually disappear on the outer part of ray, so that there remains only a series of independent, transverse, slender, skeletal bands. Even the abactinal elements of these are absorbed in *Labidiaster annulatus*. The skeletal meshes contain numerous papulae. The form and armature of the adambulacral plates are as in *Coronaster*. The arrangement of the pedicellariae either in retractile wreaths surrounding the spines or on retractile transverse cushions is not unlike that found in *Coronaster*. The mouth-plates of the Brisingidae, of *Coronaster*, *Pedicellaster*, and of *Labidiaster* are similar in general form, those of *Labidiaster* being relatively the smallest.

The features which are chiefly relied upon to distinguish the Brisingidae, and to which the family in part owes its characteristic appearance, are conspicuous by their different form in *Labidiaster*. Such, in the Brisingidae, are the elongate and peculiarly

formed adambulacral plates; the long needle-like subambulacral and marginal spines, with their characteristic sacculate sheaths; the variable but always non-reticulate abactinal skeleton of the rays; the presence of only crossed pedicellariae.

The genus *Rathbunaster* is notable for the suppression of the alternate superomarginal plates and the reduction of the abactinal skeleton to spaced circular plates without trace of connectives. The marginal and abactinal plates bear an acicular spine surrounded by a retractile sheath with an expanded distal crown covered with numerous pedicellariae. The ambulacral, adambulacral, and oral plates are similar to those of *Coronaster*.

In *Labidiaster*, *Coronaster*, *Rathbunaster*, and certain genera of the Brisingidae there are 2 gonads to each ray; each gonad opens upon the side of the ray at some distance from the base. All three genera, as well as the Brisingidae, have a single ampulla to each tube-foot.

Genus *Labidiaster* Lütken

Labidiaster Lütken, *Videnskab. Medd. naturh. Foren. i Kjobenhavn*, 1871, p. 289. Type *L. radius* Lütken.

Labidiastrella Verrill, 1914, p. 352. Type *L. annulatus* Sladen.

Labidiaster annulatus Sladen

(Fig. I, 3-3e)

Labidiaster annulatus Sladen, 1889, p. 595, pl. 108, fig. 1.—Koehler, 1917, p. 7, pl. 1, figs. 2, 4, 5.

Labidiaster radius Koehler, 1906, p. 24.—1912, p. 7, pl. 1, fig. 1.

Labidiastrella annulata Verrill, 1914, pp. 352, 373.

St. 148. Off Cape Saunders, South Georgia, from 54° 03' S, 36° 39' W to 54° 05' S, 36° 36' 30" W, 132-148 m., grey mud and stones, 2 specimens.

St. 156. South Georgia, 53° 51' S, 36° 21' 30" W, 200-236 m., rock, 2 specimens.

St. 159. South Georgia, 53° 32' 30" S, 36° 08' W, 160 m., rock, 1 specimen.

St. 160. Near Shag Rocks, 53° 43' 40" S, 40° 57' W, 177 m., grey mud, stones, 4 specimens.

St. 167. Off Signy Island, South Orkneys, 60° 50' 30" S, 46° 15' W, 244-344 m., green mud, 1 specimen.

St. 182. Schollaert Channel, Palmer Archipelago, 278-500 m., 1 specimen.

St. 187. Neumayr Channel, Palmer Archipelago, 64° 48' 30" S, 63° 31' 30" W, 259 m., mud, 1 specimen.

St. 190. Bismarck Strait, Palmer Archipelago, 64° 56' S, 63° 35' W, 93-130 m., rock or stones and mud, 8 specimens.

St. 371. 1 mile east of Montagu Island, South Sandwich Islands, 99-161 m., 3 specimens.

St. MS 68. East Cumberland Bay, South Georgia, 220-247 m., 2 specimens.

St. 1873. Off Clarence Island, South Shetland Islands, 61° 20.8' S, 54° 04.2' W, 200-137 m., 2 specimens.

St. 1955. South Shetland Islands, 61° 35.1' S, 57° 23.3' W, 440-410 m., 2 specimens.

The smallest specimen (St. 160), with R 15-17 mm. and r 4 mm., has 16 subequal rays and the bud of a new one. The specimen with longest rays (St. MS 68) with R 340-370 mm. and r 45 mm. has 45 rays. Of these, 21 are only 15-50 mm. long and represent regenerating rays from margin of disk. The following are the maximum number of rays observed: 47 rays, R 270 mm. (St. 156); 48 rays, R 260 mm. (St. 167);

49 rays, R 185 mm. (St. 1955); 50 rays, R 180 mm. (St. 167). So far as I am aware this is the greatest number of rays observed in any sea star and is slightly in excess of twice the maximum number (24) ever reported for the large north Pacific *Pycnopodia helianthoides*.

The outstanding characters of this species are the very large crossed pedicellariae carried by the abactinal transverse integumentary welts of ray; and the rapid atrophy of the abactinal skeleton beyond the proximal third of the ray. At first the longitudinally oriented ossicles of the skeleton disappear leaving rather widely spaced transverse arches of slender plates, corresponding to the lateral pairs of marginals. Then the abactinal elements of these arches disappear, leaving the marginal plates, which become smaller and smaller as end of ray is approached. On the outer third of ray they are scarcely more than rudiments. A very small inferomarginal spinelet persists nearly to end of ray but is quite hidden by the thick integument and pedicellariae.

The transverse welts, or thickening, of the integument, which proximally overlies the skeletal arches, are continued to the end of the ray and are more prominent after the disappearance of the abactinal plates. These heavier cushions distal to the region of more or less complete abactinal skeleton carry the largest pedicellariae in considerable numbers, as shown by Koehler's figures (1917, pl. 1, figs. 2, 4). Over the proximal, so-called genital area, the crossed pedicellariae are fewer and smaller, their place to some extent being taken by numerous large and small laceolate straight pedicellariae.

On fully grown specimens (e.g. with R 180 mm.) the characteristic large crossed pedicellariae are 1–1.5 mm. long and on the largest examples upward of 1.75 mm. long (Fig. 1, 3). On the marginal spines and proximal abactinal plates are numerous smaller pedicellariae approximately 0.4 mm. (Fig. 3c); and on the outer adambulacral spines a cushion of still smaller ones, 0.25–0.3 mm. (Fig. 3b).

Crossed pedicellariae are practically absent from the disk, but in place of them are very numerous small and large lanceolate straight pedicellariae, the largest as long as the acicular spinelets but much thicker.

Sladen does not mention the mouth-plates. They are more easily observed in small than in large specimens, for in the latter the entire circumference of actinostome is a *cheval-de-frise* of crowded spines and very numerous large straight pedicellariae which hide the plates. In a small specimen, with disk-diameter 25 mm. and 36 rays, the inner end of all but 5 of the ambulacral furrows is bridged by a fusion of the inner lateral angles of the mouth-plates of either side of furrow. In a large specimen with 49 rays only 4 furrows are open at the inner end. This is obviously caused by a crowding of the mouth angles. The organic bridge consists at first of tissue only, but as growth proceeds the opposing plates are wedged tightly together so that at best only a narrow suture separates them. In old examples actual ankylosis takes place. In early stages a sort of epineural tube represents the inner end of the ambulacral furrow, but in later stages of fusion this tube is often very small—so small in fact that one wonders how the radial nerve avoids compression during active movements of the animal. The armature of the plates is variable, partly due to suppression of the lateral marginal spines by this fusion. Each plate has on the actinostomial margin adjacent to median suture a prominent

slender acicular spine and two shorter ones at mouth of furrow. One or both of these lateral spinelets may be suppressed by fusion of plates. Actually the actinostomial margin of the combined mouth-plates of any oral angle carries 2 or 3 unequal spines, except when one "corner" has failed to fuse. On that particular plate there are 3 spines, the apical and 2 laterals. The companion plate of that angle (if fused with its *vis-à-vis* of the next angle) has only the apical spine surviving. The very constricted outer part of each oral pair carries 1-3 prominent slender acicular suborals irregularly placed.

The circle of mostly fused mouth-plates overhangs the outer part of the peristome so that the circumoral nerve is at the rear, or bottom, of a rather deep groove above the projecting oral angles. The *cheval-de-frise* of spines and large pedunculate straight pedicellariae evidently provide an efficient protection to the nerve.

Behind the oral pair of plates there is an extensive adoral carina composed of 6-8 pairs of juxtaposed adambulacral plates of adjacent rays. Each of these plates carries 1 spine, the inner of the pair characteristic of adambulacrals of the free part of the ray.

In spite of a certain amount of variation in detail, the two species of *Labidiaster* are easy to distinguish, the general habit of medium-sized specimens being well shown by Sladen's figures which, however, do not do justice to the disparity in size of the crossed pedicellariae. In *radiosus* these pedicellariae are not only smaller, but differ slightly in detail. The skeletal arches, in a rudimentary form, persist to the end of ray. The disk is smaller, while a scattering of primary spines is conspicuously larger than the secondaries; in *annulatus* there is no such disparity, the spines being uniformly small and more numerous. In *radiosus* straight pedicellariae are not numerous, but this feature may prove to be variable.

In young specimens of *annulatus* (e.g. R 50 mm., r 12 mm.) the transverse skeletal arches persist to the end of the ray as in adult *radiosus*. Verrill made a "book-genus", *Labidiastrella* for *L. annulatus*,¹ based upon the absence of the dorsal skeleton distally. The difference between *radiosus* and *annulatus* in this respect is one of degree, not kind. The abactinal skeleton of *radiosus* is incomplete distally, but the degeneration has not been carried so far as in *annulatus*. Compensating for the loss of abactinal plates, *annulatus* has developed a remarkable equipment of crossed pedicellariae of very large size.

As in *Pycnopodia*, the loss of the abactinal skeleton undoubtedly confers a high degree of flexibility to the rays. Active prey can be detained long enough by the large crossed pedicellariae for the tube-feet of adjacent rays to be brought into action. Rapid torsion of rays is of distinct advantage. In the stomach of a rather small example, with disk diameter of 30 mm., are fragments of a *Euphausia* (probably *superba*) about 40 mm. long (St. 190). A specimen from St. 371 and one from St. 1955 have captured isopods; one from St. 148 contains a small ophiuran. In general the mouth is widely open and sometimes the stomach is partly everted.

Koehler's records of *L. radiosus* from the Antarctic Archipelago refer to *L. annulatus*. His figure (1912, pl. 1, fig. 1) of a specimen from 64° 48' S, 65° 51' W is clearly referable to *annulatus*.

¹ Verrill, 1914, p. 352.

TYPE LOCALITY. Not stated. Original specimens from 75 to 150 fathoms off Kerguelen and Heard Islands and between the two.

DISTRIBUTION. South of the Antarctic Convergence: Kerguelen, Heard; Antarctic Archipelago; South Orkneys, South Sandwich Islands, South Georgia, Shag Rocks; 93–440 m.

The record of this species from Challenger St. 191, 800 fathoms, Arafura Sea needs confirmation by new material.

Labidiaster radiosus Lütken

(Fig. I, 2–2*b*)

Labidiaster radiosus Lütken, *Videnskab. Medd. naturh. Foren. i Kjobenhavn*, 1871, p. 293.—Studer, 1884, pp. 14–25, pls. 2, 3, fig. 4*a–y*.—Sladen, 1889, p. 595, pl. 108, fig. 2.—Perrier, 1891, p. 72, 149–159, pl. 8, figs. 2–11.—Ludwig, 1903, p. 58, pl. 4, fig. 39; 1905, p. 71.—Koehler, 1917, pl. 1, fig. 3.—1923, p. 6, pl. 1, fig. 3.

Labidiaster crassus Koehler, 1923, p. 7, pl. 1, figs. 1, 2.

St. 48. 8.3 miles north, 53° E of William Point Beacon, Port William, East Falkland Island, 105–115 m., 3 specimens.

St. 51. Off Eddystone Rock, East Falkland Island, 105–115 m., fine sand, 18 specimens.

St. WS 72. Falkland Islands, 51° 07' S, 57° 34' W, 79 m., sand and shell, 5 specimens.

St. WS 79. Falkland Islands, 51° 01' 30" S, 64° 59' 30" W, 131–132 m., fine dark sand, 5 specimens.

St. WS 83. 14 miles south, 64° W of George Island, East Falkland Island, 137–129 m., fine green sand and shell, 1 specimen.

St. WS 84. 7½ miles south, 9° W of Sea Lion Island, East Falkland Island, 75–74 m., coarse sand, shell, stones, 17 specimens.

St. WS 91. Tierra del Fuego, 52° 53' 45" S, 64° 37' 30" W, 191–205 m., fine dark sand and shell, 1 specimen.

St. WS 93. West Falkland Island, 51° 51' S, 61° 30' W, 133–130 m., grey sand, 1 specimen.

St. WS 97. Falkland Plateau, 49° 00' 30" S, 61° 58' W, 146–145 m., 1 specimen.

St. WS 225. Falkland Islands, 50° 20' S, 62° 30' W, 162–161 m., green sand, shells and pebbles, 1 specimen.

St. WS 226. Falkland Islands, 49° 20' S, 62° 30' W, 144–152 m., 1 specimen.

St. WS 249. Falkland Islands, 52° 10' S, 57° 30' W, 166 m., fine brown and green sand, shells, stones, 1 specimen.

St. WS 583. Falkland Islands, 53° 39' S, 70° 54½' W, 14–78 m., 1 specimen.

St. WS 801. South-east of Cape Tres Puntas, 48° 26¼' S, 61° 28' W, 165 m., 1 specimen.

St. WS 824. Falkland Islands, 52° 29¼' S, 58° 27¼' W, 146–137 m., 3 specimens.

St. WS 825. Falkland Islands, 50° 50' S, 57° 15¼' W, 135–144 m., 1 specimen.

This species has been erroneously reported from the Antarctic Archipelago by Koehler, as noted under synonymy of *L. annulatus*. Even specimens from as near the Falkland area as Shag Rocks are referable to *annulatus*.

The two species are readily distinguishable by the persistence, in *radiosus*, of the abactinal arcs of plates to the end of the ray; by the smaller crossed pedicellariae of the transverse integumentary cushions, relatively few abactinal straight pedicellariae, and by large primary abactinal spines of disk in addition to distinctly smaller secondary ones. Although there are no specimens of *radiosus* large enough to compare with the fully

grown examples of *annulatus*, in medium-sized examples of comparable size (e.g. 100 mm.) there is a decided difference in the dimensions of the largest crossed pedicellariae. These are 0.55–0.65 mm. in *radiosus* and in *annulatus*, 0.9–1.3 mm. In fully grown examples of *annulatus* they are still larger (1.75 mm.). In addition to these large pedicellariae there are also perfectly formed small ones on the order of 0.2 mm. long in *radiosus* and 0.27–0.4 in *annulatus*. Slight differences in details are observable in the crossed pedicellariae of the two species (see figures).

Fusion of the mouth-plates occurs in this species as in *annulatus* and has been noted and figured by Perrier (1891, p. 73, pl. 8, fig. 4). In a specimen with 34 rays and disk diameter of 35 mm. (R 95 mm.) there are only 5 scattered furrows which are "open" at the adoral end. There are rather fewer oral straight pedicellariae than in *annulatus*. The adoral carina is composed of 5–7 pairs of adambulacral plates.

Labidiaster crassus Koehler, without locality, seems to be a variety of *radiosus* with stout, abnormally short rays.

In the stomachs of several individuals from St. 51 were found the remains of Serolid isopods. At this station were taken 3 species of *Serolis*—*schythi*, *convexa*, *exigua* (see Sheppard, 1933, *Discovery Report*, VII, p. 259). There were 5 young *Munida*, looking like *gregaria* (identifications by Mr Dilwyn John).

DISTRIBUTION. The Falkland plateau and southern end of South America, north to latitude 41° S on the Pacific coast and to 38° S on the Atlantic; 0–183 m.

Subfamily COSCINASTERIINAE Fisher

Coscinasteriinae Fisher, 1923, p. 249.—1928, p. 93 (key to genera).

Genus *Lethasterias* Fisher

Lethasterias Fisher, 1923, p. 258; 1928, p. 131. Type *Asterias nanimensis* Verrill.

Lethasterias australis sp.nov.

(Fig. L, 1–1 g, 2; Plate XVII, fig. 5)

DIAGNOSIS. R 32 mm., r 7 mm., br 7 mm. Resembling a small *Sclerasterias* abactinally; ray pentagonal in section, swollen beyond base. Differing from north Pacific forms in lacking unguiculate straight pedicellariae, blackish tips to abactinal spines, and in the different form of the straight pedicellariae which have a more extensive terminal lip.

DESCRIPTION. The type strongly resembles a small *Sclerasterias* but is debarred from this genus by the presence of a cushion of crossed pedicellariae on both inferomarginal spines and by the absence of even any sign of an enlarged lateral tooth on the terminal lip of the crossed pedicellariae. In *Distolasterias* the crossed pedicellariae have an even more conspicuously enlarged terminal tooth on each side of the terminal lip.¹ The abactinal surface slopes downward on either side of the carinal ridge to the superomarginal plates, each carinal and superomarginal plate carrying 1 stout capitate spine, the swollen end being vertically grooved. Smaller, well-spaced dorsolateral spines are

¹ See Fisher, 1928, p. 95, pl. 60, figs. 1–3.

scattered between these two series in the equivalent of two irregular longiseries. All carry heavy basal wreaths of crossed pedicellariae which increase in size from the carinal (0.27–0.36 mm.) to the superomarginal (0.40–0.45 mm.). The lateral, vertical face of ray is about half as wide as the dorsolateral. The first 5–8 inferomarginals carry 1 spatulate, heavy spine, then two until near end of ray where there may be either 1 or 2. Each spine, or pair of spines, carries a pad of crossed pedicellariae on the upper and outer side. (For form and dimensions of spines see Fig. L, 1a–1e). Between the inferomarginals and adambulacrals is a short series of slender, spineless actinal plates hidden by the integument.

The adambulacrals are regularly diplacanthid except the first 1, 2, or 3. The spines are subterete, round-tipped, relative to the inferomarginals, rather slender. Each narrow mouth-plate has 1 long and 1 short actinostomial spine, and 1 still longer suboral like the first few adambulacrals. The first pair of adambulacrals are in close contact behind the mouth-plates, the second and third pairs not so close; the fourth pair definitely separated.

The abactinal skeleton is not very regular. The carinal plates imbricate directly one with the other but form a sinuous series. The spiniferous dorsolaterals do not form well-defined longiseries and it seems probable that in an older specimen the skeleton will lose rather than gain in regularity, as in the case of *L. nanimensis*. The surface of the superomarginal plates lacks any trace of hyaline pebbling such as is found in *Sclerasterias*.

Good sized papulae occur singly or in two's on the dorsolateral area and disk; singly along the intermarginal channel; and a short series proximally in the actinal channel. Integument thick and wrinkled.

In addition to the characteristic crossed pedicellariae, which occur on abactinal and marginal spines, there is a moderate number of lanceolate, pedunculate straight pedicellariae on the mouth and adambulacral plates (furrow face), and 1 or 2 on each actinal interradiar area (0.75 mm. long).

Madreporite small, sunken, situated at mid-r.

Gonads rudimentary.

TYPE LOCALITY. St. WS 235, 47° 56' S, 61° 10' W, 155 m., 1 specimen.

REMARKS. The type is immature and the species possibly attains a large size, as in the case of *L. nanimensis* and *L. nanimensis chelifera*.¹ It is not improbable that such large specimens will be provided with unguiculate straight pedicellariae. The crossed pedicellariae of *australis* have a more extensive terminal lip than is found in the northern forms. This is most easily appreciated by a comparison of drawings of lateral views (Fisher, 1928, pl. 60, figs. 4, 5).

Genus *Notasterias* Koehler .

Notasterias Koehler, 1911, p. 35. Type *N. armata* Koehler.—Fisher, 1930, p. 243.

Autasterias Koehler, 1911, p. 38. Type *Asterias pedicellaris* Koehler.—Fisher, 1930, p. 244.

Notasteriinae Fisher, 1930, p. 243.

DIAGNOSIS. With crossed pedicellariae of a peculiar type, sometimes of very large size, having hooked terminally crossed, somewhat falcate jaws, the bases of which flare

¹ Fisher, 1928, pp. 132, 134.

apart to accommodate an unusual development of muscles (*macrocephalus* Koehler); together with a less modified form (*pirocephalus*), and conventional crossed pedicellariae. Dorsal skeleton and spines essentially as in less modified Coscinasteriinae, consisting of large, cruciform typically monacanthid carinals (alternating sometimes with secondary smaller plates) which connect with similar superomarginals by short transverse arcs of a few plates; marginals large, cruciform, monacanthid; 1 series of monacanthid actinals; papulae in 2 dorsolateral, 1 intermarginal, and, in one species, 1 actinal series; adambulacral plates predominantly diplacanthid, or monacanthid, or a combination of the two, the spines without attached pedicellariae; major pedicellariae attached to spine sheath at base of spine, or aggregated in wreaths on collar-like thickenings of the sheath, or scattered over dorsal surface; gonads in one species (*armata*) open ventrally.

REMARKS. In the light of the Discovery material it is not possible to maintain *Autasterias* on the basis of the number of adambulacral spines. Its type species (*pedicellaris*) is probably immature. *Autasterias bongraini*, as shown below, is not exclusively monacanthid; and it more closely resembles the diplacanthid *Notasterias stolophora* than it does the type of *Autasterias*. Both *Autasterias pedicellaris* and *Notasterias haswelli* have the major pedicellariae attached to plates rather than to the spine sheaths, as have the other species. The one has predominantly monacanthid adambulacrals, the other diplacanthid. It is not at all clear that these two constitute a natural generic group.

There is nothing in the structure of the skeleton and spines which justifies the removal of *Notasterias* from the Coscinasteriinae. The shape of the plates (Fig. K, 1) and distribution of the single spines are as in typical Coscinasteriinae—even to occurrence of spines on alternate superomarginals and carinals. The macrocephalous pedicellariae (which are sometimes absent) have not diverged further from the normal crossed type than have the peculiar falcate straight pedicellariae of *Pisaster* from the conventional straight pedicellaria. I have therefore placed the Notasteriinae in the synonymy of the genus.

Notasterias armata Koehler

(Fig. J, 2*a*, 4–4*b*; Fig. K, 1)

Notasterias armata Koehler, 1911, p. 39, pl. 5, figs. 6–11; pl. 6, figs. 1–8.—1912, p. 25, pl. 1, fig. 8.—1920, p. 58, pl. 7, figs. 7–9; pl. 8, figs. 2–8; pl. 9, figs. 1–6; pl. 10, figs. 1–9; pl. 60, fig. 1; pl. 61, fig. 1.—Fisher, 1930, p. 244.

St. 1658. Ross Sea, 76° 09.6' S, 168° 40' E, 520 m., 1 specimen.

St. 1660. Ross Sea, 74° 46.4' S, 178° 23.4' E, 351 m., 3 specimens.

Koehler has described and figured this species in great detail. It is remarkable for the large size of the macrocephalous pedicellariae, of which 1, and rather seldom 2 or 3, are attached to the base of the carinal and superomarginal spines (R 66 mm., St. 1658). The inferomarginal pedicellariae are much smaller and simpler. Two or three are attached to the spine sheath above the base, while on the actinal spines similar ones are at about mid-height. It is probable that even the giant pedicellariae can be elevated to end of the spine. The largest macrocephalous pedicellariae measure 3 mm. in length and 2 mm. broad at base. I find no minor crossed pedicellariae, nor spatulate straight pedicellariae.

There is much variation in the frequency of diplacanthid adambulacral plates. In the largest specimen (R 66 mm.) only the plates of the proximal third of ray are diplacanthid, the rest having 1 spine, with a few scattered plates bearing 2.

There is no trace of papulae between the inferomarginal and actinal spines, nor any between the latter and adambulacral plates.

In the largest specimen, on the actinal surface on either side of interradiial line, and between inferomarginal and actinal plates, is what I interpret as a gonopore. There are thus two in each actinal interradiial area. The gonads are attached to body wall at lower end of first superomarginal plate, thus well above the pore.

DISTRIBUTION. Ross Sea and South Victoria Land, 30–351 m.; Antarctic Archipelago (Alexander I Island), 297 m.; latitude $64^{\circ} 32'$ to $66^{\circ} 55'$ S and longitude 92° to $145^{\circ} 51'$ E, 60–354 fathoms; hence probably circumpolar.

Notasterias stolophora sp. nov.

(Fig. J, 1–1e, 2b; Plate XVII, fig. 4)

DIAGNOSIS. Differing from *N. armata* in having smaller macrocephalous pedicellariae distributed in true circumspinal wreaths on the carinal plates and half wreaths on the marginal, and in having actinal papulae. R 27 mm., r 6.5 mm., br 7 mm. Colour in life pale yellow-green.

DESCRIPTION. Spines subequal, prominent, spaced, with compressed, truncate or subclavate tips, in 5 longiseries. The carinal spines are on every plate on the proximal third of ray, then on alternate plates. The superomarginals are generally in alternate plates, while each inferomarginal plate carries 1 spine. The carinal plates carry prominent wreaths of pedicellariae while the marginals have half-wreaths on the upper or adcarinal side. The skeleton is similar to that of *N. armata*. There are two dorsolateral series of single papulae (1 series close to carinals and 1 close to superomarginals), 1 intermarginal series, and a short actinal series, comprising 3–5 single papulae. The intermarginal papulae, mostly single, are large and the intermarginal area is as broad as the dorsolateral.

Integument thick and wrinkled, as are the spine sheaths except at spine tips where skin is strongly contracted. Well-defined transverse channels extend from dorsal surface between marginal plates to ambulacrum and include between them usually three adambulacral plates.

Adambulacral plates diplacanthid except for first 1–3, which are monacanthid. Spines slender, terete, blunt, subequal to inferomarginals but much less robust. At each mouth angle are 4 spines, the middle pair longer than the lateral spine and shorter than the adambulacrals. Behind these are two prominent suborals slightly larger than adambulacrals. The adoral carina is composed of the first 2 pairs of adambulacral plates.

Crossed pedicellariae are solely of the large macrocephalous variety in different stages of development. When fully developed they are 0.75–0.8 mm. long and 0.3–0.4 mm. broad at the basal piece. They are thus very much smaller than in *armata*, as

well as different in form. They are characteristically more numerous, since the heavy spine-sheaths carry at about mid-height of the disk and carinal spines 5–8 in a complete wreath. On the side of the superomarginal spines toward carinals there are 1–5, and on the inferomarginals 1–3 on the upper side. Along the furrow face of adambulacral plates is a moderate number (which will undoubtedly increase with age) of lanceolate pedicellariae. Typical pedicellariae from different locations are figured.

The presence of 1 or 2 rudimentary actinal spines probably indicates that the series is well developed in large specimens, as are probably also dorsolateral spines. Madreporic plate small, situated at mid-r on outer side of a small primary interradiial spine.

TYPE LOCALITY. St. 1872, east of Joinville Island, Antarctic Archipelago, 63° 29.6' S, 54° 03.1' W, 247 m., 2 specimens, 1 very small (R 6.5 mm.).

REMARKS. There is no chance of confusing this species with *N. armata*, which carries 1 or 2 enormous major pedicellariae at the base of abactinal and superomarginal spines. *N. haswelli* has uniformly small major pedicellariae (usually 0.45 mm. in length) which are distributed in great abundance all over the dorsal surface. These pedicellariae resemble those of *stolophora* in having short "handles" to the blades, or jaws. These handles are more developed however than in *stolophora*, much less so than in *armata* and *bongraini*. The pedicellariae alone will distinguish the form I have called *bongraini* in which the large (1.8–2 mm. long) major pedicellariae are attached to the thickened sheath of the carinal spines, forming what is essentially a circumspinal wreath.

The young specimen has R 6.5 mm., r 2.5 mm., 6 carinal, 6 superomarginal, 6 or 7 inferomarginal spines. The major crossed pedicellariae, few in number, are at the stage of development shown in Fig. J, 1d.

Notasterias bongraini (Koehler)

(Fig. J, 3–3a, 2c, d, e)

Autasterias bongraini Koehler, 1912, p. 26, pl. 2, figs. 10, 11; 1920, p. 74, pl. 6, figs. 5–10; pl. 59, fig. 1.—Fisher, 1920, p. 244.

St. 1957. Off south side Clarence Island, South Shetlands, 830 m., 3 specimens.

The largest specimen measures R 53 mm., r 10 mm., br 11–12 mm. The other two are small having R 17 and 20 mm.

Although Koehler's original specimens were taken at King George Island, South Shetlands, 420 m., the Discovery specimens are different in having more numerous macrocephalous pedicellariae and by no means uniformly monacanthid adambulacral plates. In the large specimen, for instance, in one adambulacral series chosen at random the following plates, counting from base of ray, have 2 spines: 15, 28, 38, 48, 52, 54, 56, 72, 79, 81, 88, 89 (series ends at 106). The incidence on another ray is 2, 10, 11, 15, 16, 17, 40, 51, 52, 67, 69, 75. Although Koehler states that the adambulacral spines are in a single series, the photograph of a type (1912, pl. 2, fig. 11) shows a very few diplacanthid plates. Of the two small specimens one has very few diplacanthid plates while in the

other they are as numerous as in a young example of *armata* (R 17 mm.) where some of the proximal plates and all of the distal half of ray are monacanthid.

The macrocephalous pedicellariae are closely similar to those figured by Koehler (1920) but are more numerous in the large specimen where the carinal plates carry a battery of from 2 to 5 and disk spines, 5–8, attached to the swollen base of the spine sheath. A short series of dorsolateral spines carries 1 or 2 of these major pedicellariae. The superomarginal spines have a complete wreath of ordinary pedicellariae extending half the height of spine, and in addition the proximal spines carry 1 or 2 major pedicellariae. The inferomarginals each have a thick pad of numerous minor pedicellariae on the outer side, while actinals are similarly armed with about 10 minor pedicellariae. The inferomarginal spines are all united at the base by a web of skin which would obviously be broader if the pads of pedicellariae were advanced to the end of spines. The prominence of this ventrolateral web (which is present in *N. armata*) depends upon the contraction of sheath muscles. A similar web occurs in typical Coscinasteriinae.

There is no trace of actinal papulae.

The young specimens (R 17 and 20 mm.) already have the minor crossed pedicellariae developed on supero- and inferomarginal spines, whereas in the much larger *armata* and *stolophora* they are absent. These small specimens also carry 1 or 2 macrocephalous pedicellariae at base of the central, primary radial, and about half of the carinal spines. Some of them belong to the pirocephalous variety of Koehler and appear to be incompletely developed macrocephalous, lacking the long hyaline spine at end of jaw.

I do not believe a generic distinction, based upon number of adambulacral spines, can be drawn between *N. armata* and *N. bongraini*.

DISTRIBUTION. South Shetland Islands, 420–830 m., latitude $65^{\circ} 42'$ to $66^{\circ} 55'$ S, longitude $92^{\circ} 10'$ to $145^{\circ} 21'$ E, 60–318 fathoms.

Notasterias species

St. 195. Admiralty Bay, King George Island, South Shetlands, 391 m., 3 specimens.

St. 599. West coast of Adelaide Island, $67^{\circ} 08'$ S, $69^{\circ} 06\frac{1}{2}'$ W, 203 m., 1 specimen.

The specimen from St. 599 has R 18 mm. and definitely *diplacanthid* adambulacrals. There are no specialized major pedicellariae. The carinal, some of the few dorsolateral, the superomarginal, and inferomarginal spines carry 1 or sometimes 2 normal crossed pedicellariae, *circa* 0.4 mm. long, resembling those of *N. bongraini* (Fig. 3a) but with a straighter terminal lip as seen in profile. Along the furrow margin at base of about every third or fourth spine is a broadly lanceolate straight pedicellaria.

The largest specimen from St. 195, representing probably a second species, has R 15 mm. and monacanthid adambulacrals. It has a few normal straight pedicellariae but no major pedicellariae. The other specimens (R 8 and 5 mm.) have still fewer crossed pedicellariae. The largest specimen has only a few furrow straight pedicellariae, the others none.

The important feature of these specimens is the absence of the specialized major

crossed pedicellariae. These are present in an example of *N. bougraini* having R 17 mm., and in one of *stolophora* as small as 6.5 mm., so that age alone cannot account for their absence. It may well be that they do not occur in some of the less specialized species of the genus.

Genus *Psalidaster* nov.

DIAGNOSIS. Superficially resembling *Saliasterias* Koehler, but differing in having large, crossed pedicellariae of *Notasterias* type, abactinal and marginal spines single, the latter (surrounded by rosettes of crossed pedicellariae) forming two prominent lateral series. Abactinal and intermarginal papulae; no actinal plates or papulae; adambulacral plates diplacanthid, sporadically monacanthid and triplacanthid; actinostome small, mouth-plates small, adoral carina, long, narrow (5 or 6 plates); ambulacral furrow not abnormally wide; tube-feet slender, four ranked; abactinal skeleton proximally very irregularly reticulate, weak, disintegrated distally into separated small primary plates; gonopores conspicuous, two to each constricted actinal interradian area.

Type *Ps. mordax* sp. nov.

REMARKS. This new polybrachiate type cannot be confused with either *Saliasterias* Koehler or *Cryptasterias* Verrill, since its crossed pedicellariae, nearly 1 mm. long, have a highly characteristic form totally unlike the very small conventional pedicellariae of the above named genera. This is rather a fortunate circumstance for the abactinal skeleton, like that of so many Antarctic Asteroiidae, is weak, reticulated, and without any special clues to relationship; while the mostly monacanthid marginals are also without outstanding characteristics. The ovaries are small with large eggs, as in *Cryptasterias*, and open ventrally. The skin, though soft and finely wrinkled, is not of the thick pustulate type characteristic of *Cryptasterias*.

The crossed pedicellariae resemble those of *Notasterias* in having a broad base for the accommodation of heavier muscles, the jaws being swollen, with a large cavity. The constricted distal end of the jaw is produced into two principal teeth which interlock with those of the other jaw, instead of crossing. The suppression of one tooth would produce a pedicellaria closely similar to those which predominate on the inferomarginal and actinal spines of *Notasterias armata* (compare Fig. J, 4*b* with Fig. K, 2*f*, 2*g*).

As to the place of this genus in the system, I believe that it may be regarded as allied to Coscinasteriinae rather than to typical Asteroiinae such as *Diplasterias*.

Psalidaster mordax sp. nov.

(Fig. K, 2-2*g*, 3-3*b*; Plate XVIII, figs. 1, 2)

DIAGNOSIS. Rays 11; R 135 mm., r 27 mm., br 15-16 mm. Paratype R 110 mm., r 23 mm., br 12 mm. Rays flexible, slender, with evenly convex pliant abactinal surface uniformly beset with short soft papillae representing small spinelets, their associated crossed pedicellariae and smaller interspersed papulae; abactinal skin soft, not thick, not thrown into heavy welts, although finely wrinkled; marginal spines larger than abactinal, in two regular longiseries, carrying rosettes of pedicellariae; no actinal plates;

adambulacral spines 2 (varying to 1 or 3), long, slender, terete, in a transverse series; actinostome small, mostly occluded by the long teeth (a pair to each mouth angle); furrows not wide; tube-feet slender, 4 ranked.

DESCRIPTION. The convex abactinal wall is beset with widely spaced slender acicular thorny spinelets (0.9–2 mm. long), the retracted sheath of which forms a soft collar at the base and carries 1 or 2 to 5 or 6 characteristic crossed pedicellariae. The integument is soft and until dried hides the skeleton. Between the spines are abundant papulae, singly or in two's and three's, and here and there a lanceolate straight pedicellaria. In alcoholic specimens the abactinal surface, under low magnification, has the appearance of being covered with low papillae—a confused mixture of papulae, skin-covered pedicellariae and spinelets. There is considerable difference between the two specimens in the number of pedicellariae. In the smaller, most of the abactinal spinelets of ray carry 1 or 2, and of the disk 2 or 3; whereas in the type the number is 5 or 6 for ray and 5–10 for disk. Madreporic body small (3 mm. diameter), situated at mid-r.

On the side of the ray are two longiseries of acicular spines conspicuously larger than the abactinal and surrounded by thick basal collars of crossed pedicellariae like the abactinal. The upper or superomarginal are 2–2.25 mm. long by 0.35 mm. just above base and carry 6–8 crossed pedicellariae, while the inferomarginal spines (sometimes 2 spines to a plate) are 2.9 mm. long by 0.5 mm. thick at base, and the fleshy sheath carries upward of 25 crossed pedicellariae. The spines correspond to about every fourth adambulacral plate and as the superomarginal plates are oriented obliquely to the inferomarginals the superomarginal spine is usually above the interval between 2 inferomarginal spines. There is a series of single inconspicuous intermarginal papulae which may represent encroachments of the abactinal system.

Between the inferomarginal and outer adambulacral spine is a narrow zone of bare skin devoid of papulae. The adambulacral spines are usually two in a transverse series on the inner half of plate; often there are 3, or only 1. They are long, slender (proximally 3.5 by 0.4 mm.), blunt, of nearly uniform diameter, and the proximal are a little longer than the inferomarginals. The furrow face of the adambulacral plates carries numerous small pedunculate straight pedicellariae of the common lanceolate form, 0.6–0.7 mm. in length, and 0.35 mm. broad at base.

The mouth-plates are small with a narrow actinostomial border, there being at each mouth angle two long "teeth" extending over the peristome; at outer end of each mouth pair are two spines intermediate in size between the teeth and the first adambulacrals. The narrow adoral carina, just back of mouth-plates, is composed of 5 or 6 pairs of juxtaposed adambulacrals which generally carry only one spine each; but sometimes a second smaller one is present on the fourth to sixth. The mouth-plates carry an abundance of small straight pedicellariae, exactly like the adambulacral.

Phylogenetically the abactinal skeleton is degenerating. It is composed of very numerous small plates forming a fantastically irregular reticulate structure, the irregularly spaced nodes of which are formed by 3- or 4-lobed primary plates, bearing single spinelets. The secondary plates are slender, overlapping, and the meshes are small, very

unequal in size and irregular in shape. A meandering series of slightly larger carinal plates can be readily distinguished in a prepared specimen. Their spinelets are closer together than elsewhere because the carinal plates imbricate directly, or through one spineless plate between; whereas on the dorsolateral region 3 or 4 elongate ossicles may separate two primary plates. The form and imbrication of the marginals can best be appreciated from the figure (Fig. K, 3*b*). There is no trace of actinal plates. The above obtains on the proximal half of ray. Distally the mesh-work gradually becomes disconnected through the absence of intermediate ossicles until on the outer fourth of ray there are only spaced primary spiniferous plates. What really happens, of course, is that on the distal younger part of the ray the primary plates appear first, and only later, during further growth, the connecting ossicles develop. On the distal part of the ray the inferomarginals imbricate in a complete series. To the upper lobes of each is imbricated an oblique superomarginal. These are separated one from another by a conspicuous interval of membrane, encroached upon sometimes by a small disconnected abactinal plate. Even on the proximal half of ray the superomarginal plates are sometimes disconnected; or they are joined directly by overlapping lobes or by intermediate plates belonging to the abactinal system.

The crossed pedicellariae are diagnostic and recall those characteristic of *Notasterias*. The most frequent size varies between 0.7 and 0.93 mm. in length, but almost as numerous are various smaller sizes down to 0.6 mm., and a few as small as 0.5 mm. Each jaw is wide at the base and tapers to a narrow tip having 2 prominent teeth between which are usually several smaller ones. On the vertical inner edge of each jaw the denticles are numerous but very variable in details. At the attached end, the pedicellariae are wide and each jaw has a relatively large cavity for the accommodation of powerful "biting" muscles, as in the case of *Notasterias*.

The gonoducts open ventrally by prominent pores in the very constricted actinal interradiar area. The pores are not symmetrically placed side by side but one is nearer margin than the other. Those of the female (smaller specimen) are larger than in the male (type). The small ovaries are attached lower on the side of the interbrachial septum (coalesced sides of rays) than the voluminous testes. The interbrachial septum contains calcareous plates. The tube-feet are crowded into 4 ranks and their ampullae are single, pyriform, voluminous.

TYPE LOCALITY. St. WS 821. Falkland Islands, 52° 55 $\frac{3}{4}$ ' S, 60° 55' W, 351-367 m., 2 specimens.

Subfamily ASTERIINAE Verrill (emended)

Asteriinae Verrill, 1914, p. 42.—Fisher, 1923, p. 250; 1928, p. 57; 1930, pp. 2, 217 (key to genera).

Genus *Anasterias* Perrier

Anasterias Perrier, 1875, p. 81; 1891, p. 91. Type *Anasterias minuta* Perrier.—Fisher, *Smithsonian Misc. Coll.*, LII, 1908, p. 52; *Zool. Anz.*, XXXIII, 1908, p. 356; *Ann. Mag. Nat. Hist.*, ser. 9, x, 1922, p. 592; XVIII, 1926, p. 197; 1930, p. 221; 1931, p. 6.

Asteroderma Perrier, *Comptes Rendus*, CVI, no. 11, 1888, p. 763; 1891, p. 96. Type *Asteroderma papillosum* Perrier.

Sporasterias Perrier, *Expéd. Sci. Travailleur et Talisman*, 1894, p. 107, Type *Asterias rugispina* Stimpson.—Ludwig, 1903, p. 39.—Koehler, 1917, 1920, 1923.—Verrill, 1914.—Fisher, 1922, p. 596; 1923, p. 605; 1930, p. 239; 1931, p. 9.
Calvasterias Sladen (not Perrier), 1889, p. 590.
Parastichaster Koehler, 1920, p. 89. Type *P. mawsoni* Koehler.
Kalyptasterias Koehler, 1923, p. 43. Type *K. conferta* Koehler.

Anasterias is the oldest name for the group commonly called *Sporasterias*, which includes, in the Cape Horn region, a number of variable and puzzling forms having a weak, often degenerated, dorsal skeleton and a thick skin. The type species, *Anasterias minuta*, is one of these forms. The type specimen is unfortunately immature, and although probably not referable to *A. antarctica*, is obviously closely related. This relationship was clearly recognized by Perrier in 1891, in a series of 37 specimens from the Cape Horn region. He indicated that the reduced dorsal skeleton was too variable to warrant a new genus. Nevertheless, in 1894 he created *Sporasterias* for *Asterias rugispina* (= *antarctica*), using its more fully developed abactinal skeleton as the criterion of difference.

In 1903 Ludwig adopted the name *Anasterias* for a group of Antarctic, mostly small, sea stars, the first species of which was the *A. perrieri* of Studer (1885). Although this *Anasterias* of Ludwig did not include *A. minuta*, the type, it was rather generally accepted, even by Verrill, a great stickler for nomenclatorial proprieties. It was renamed *Lysasterias* by me in 1908. The matter is of minor importance since *Lysasterias* is poorly differentiated from the real *Anasterias*.

The type specimen of *A. minuta* is in the Museum d'Histoire Naturelle and is labelled E 792 M. M. Hombron et Jacquinot, 1847. It obviously takes precedence over the series of specimens brought back by the Mission Scientifique du Cap Horn (1882–1883), some of which Koehler examined and erroneously treated as types.

Perrier (1891, p. 95) arranged this series of 37 specimens into 18 groups according to the development of the abactinal skeleton in such a manner that the first members of the list have the best developed skeleton and approach nearest the characters of *Asterias spirabilis*. The last are those which have the least development of skeleton "et qui, par conséquent, présentent davantage les caractères du genre *Anasterias*". In groups 1–10 the skeleton has the best development and there are numerous abactinal spinelets; in 11–14 the dorsal spinelets of the rays become less and less numerous but those of disk are still apparent and on the disk is a pentagonal figure formed by the skeletal plates bearing each a group of spinelets. From 15 to 18 the spines and plates are indistinct, which also means that the integument is thicker.

The specimens examined by Koehler may have been derived largely from the first 10 groups of Perrier and hence have been immature *antarctica*, since 11 specimens came from "Baie Orange", from whence Perrier lists a large number of *antarctica* (as *spirabilis*).

Koehler states: "Je dois dire que j'ai eu en communication plusieurs *Anasterias minuta* du Jardin des Plantes et j'ai pu constater que toutes étaient parfaitement identique

à de jeunes *Sporasteria antarctica*." He adds the somewhat singular observation: "J'estime donc l'*A. minuta* forme jeune d'une *Sporasterias* ou peut-être d'une autre *Anasterias*, ne doit pas figurer parmi les espèces du genre *Anasterias*."

The type of *Anasterias minuta*, which is the only specimen which can fix the identity of the species, is in alcohol. The rays are short, R 12 mm., r 6 mm. The integument entirely conceals the abactinal skeleton. I treated one ray with caustic potash which revealed a fairly regular series of small carinal plates, between which and the regular series of superomarginals (each with 1 short spine) is an irregular very open incomplete net of plates, strongest next to the superomarginals. The net is in part composed of about 14 irregular transverse tongues of plates on either side, extending inward toward the carinals and each corresponds roughly to a superomarginal plate. The inferomarginals have 2 spines, which are the largest on the body and are separated from the smaller single superomarginal by a fairly broad channel provided with a row of papulae. Actinal spines not developed; adambulacral plates strictly monacanthid. The abactinal surface is soft and somewhat pulpy, but not conspicuously papillose or pustulate; abactinal spinelets few and scattered.

This specimen obviously falls within Perrier's third group, and my sketch of the abactinal skeleton of the type agrees with the skeleton of the *A. minuta* of the present report. This sketch is not essentially different from Koehler's figures of young *A. pedicellaris* (which are possibly referable to *minuta*). *A. conferta*, in the young stages, has a variably weak abactinal skeleton of the same sort, and is difficult to separate from *minuta*. *Minuta* is closely related to *pedicellaris* (some varieties of which have an abactinal skeleton as well developed as that of *antarctica* and *studerii*).

The practical difficulty of assigning names to the multitude of variants which one encounters in this complex of "small species" is very trying to the patience. One is bound to sympathize with Leipoldt who lumps them all together as one species!

Anasterias antarctica (Lütken)

(Plate XIX, fig. 1)

Asteracanthion antarcticum Lütken, *Vidensk. Meddel.*, 1856, p. 105.

Asterias rugispina Stimpson, *Proc. Boston Soc. Nat. Hist.*, VIII, 1860, p. 267.—Leipoldt, *Zeit. Wiss. Zool.*, 1895, p. 563; literature.

Asterias cunninghami Perrier, *Rév. Stell.*, 1875, p. 75.

Asterias spirabilis Bell., *Proc. Zool. Soc. Lond.*, 1881, p. 513, pl. 48, fig. 4.

Asterias verrilli Bell, *Proc. Zool. Soc. Lond.*, 1881, p. 513, pl. 47, figs. 3, 3a.

Asterias hyadesi Perrier, *Comptes-rend.*, 1886, p. 1146.

Sporasterias spirabilis Perrier, *Expéd. sci. Travailleuse et Talisman*, 1894, p. 107.

Asterias (Sporasterias) antarctica Meissner, *Arch. Naturges.*, 1896, p. 105, pl. 6, figs. 7, 7a-7b; literature.

Sporasterias antarctica Ludwig, *Expéd. antarct. Belge*, 1903, p. 39; 1905, p. 70.—Koehler, 1917, p. 10; 1920, p. 78, pl. 18, figs. 1-4; pl. 28, figs. 1-4; 1923, p. 14, pl. 7, fig. 4.—Fisher, 1930, p. 240; 1931, p. 9.

Anasterias antarctica Fisher, *Ann. Mag. Nat. Hist.*, ser. 9, XVIII, 1926, p. 197.

To this synonymy Leipoldt, 1895, p. 563, adds: *Asteracanthion varium* Philippi, *A. fulgens* Philippi, as well as several species, such as *Anasterias minuta*, *Asterias perrieri* Smith, *Asterias rupicola* Verrill, and *Calvasterias stolidota* Sladen, which I consider to be distinct.

St. 52. Port William, East Falkland Island, 17 m., 1 specimen.

St. 724. Fortescue Bay, Magellan Strait, 0-5 m., 11 specimens.

St. 1902. 49° 48.0' S, 67° 39.5' W, Cape San Francisco de Paula Lighthouse bearing 328°, distance 4 miles, 47 m., 1 specimen.

St. WS 90. 13 miles north 83° E of Cape Virgins Light, Argentina, 81-82 m., fine dark sand, 2 specimens.

St. WS 755. 51° 39' S, 57° 39' W, 77 m., 10 specimens.

St. WS 798. 47° 32' S, 65° 02' W, 49-66 m., 3 specimens.

St. WS 834. 52° 57 $\frac{3}{4}$ ' S, 68° 08 $\frac{1}{4}$ ' W, 27-38 m., 2 specimens.

St. WS 836. South-east of Atlantic entrance to Magellan Strait, 64 m., 3 specimens.

St. WS 841. Falkland Islands, 54° 11 $\frac{3}{4}$ ' S, 60° 21 $\frac{1}{2}$ ' W, 110-120 m., 2 specimens.

St. WS 848. North-east of Atlantic entrance to Magellan Strait, 50° 37 $\frac{1}{2}$ ' S, 66° 24' W, 115-117 m., 2 specimens.

The largest specimen measures R 90 mm., r 20 mm., br 22 mm. (dry); the smallest measures R 6.5 mm., r 2.5 mm. Typical specimens have a great abundance of crossed pedicellariae all over the abactinal surface (on the plates and around the borders of the papular areas), around the superomarginal spines, and on the upper side of outermost inferomarginal spine. In the interradiial channels there is a variable number of conspicuous straight pedicellariae considerably longer than broad, either tapered or blunt ended while a variable number of similar ones are found in the actinal and intermarginal channels. In little specimens they are entirely lacking. Along the ventrolateral border of ray is a series of oblique combs of 3 or 4 spines the innermost of which is an actinal, the others inferomarginal. There is a series of actinal papulae. Very small specimens lack actinal plates, spines, and papulae, or have only a short series.

In this species the abactinal skeleton is normally stout, but specimens are occasionally met with in which the skeleton is weak and the crossed pedicellariae few in number (Teal Inlet, Falkland Islands, Fisher, 1931, p. 8, pl. 8). In young examples the abactinal skeleton is nearly always weak and only a little better developed than in small examples of *minuta*. The latter differs in having a thicker pustulate skin, few abactinal spinelets and few pedicellariae.

Anasterias studeri Perrier

(Plate XIX, fig. 2)

Anasterias studeri Perrier, 1891, p. 99.—Koehler, 1920, p. 13, pl. 2, fig. 6; pl. 12, fig. 11; pl. 57, fig. 2.
Lysasterias studeri Fisher, 1930, p. 236.

St. WS 91. Tierra del Fuego, 52° 53' 45" S, 64° 37' 30" W, 191-205 m., fine dark sand, 11 specimens.

St. WS 92. 51° 58' 30" S, 65° 01' W, 145-143 m., 11 specimens.

St. WS 93. West Falkland Island, 133-130 m., 1 juv.

St. WS 814. 51° 45 $\frac{1}{4}$ ' S, 66° 40' W, 111-118 m., 1 specimen.

St. WS 816. 52° 09 $\frac{3}{4}$ ' S, 64° 56' W, 150-160 m., 2 specimens.

St. WS 818. 52° 31 $\frac{1}{4}$ ' S, 63° 25' W, 272-278 m., 1 specimen.

St. WS 847A. Off Porto Santa Cruz, Argentina, $50^{\circ} 15\frac{3}{4}'$ S, $67^{\circ} 57'$ W, 51–56 m., 3 specimens, intermediate.

St. WS 847B. Off Porto Santa Cruz, Argentina, $50^{\circ} 18\frac{3}{4}'$ S, $67^{\circ} 44'$ W, 56–84 m., 6 specimens, intermediate.

St. WS 867. $51^{\circ} 10'$ S, $64^{\circ} 15' 30''$ W, 150–147 m., 2 specimens.

Typical large examples are very distinct from *antarctica* by reason of the abundance of large triangular straight pedicellariae, the jaws of which are as broad at base as the height. There is a good representation of apparently fully grown specimens. The largest measures R 110 mm., r 30 mm., br 25 mm. In addition to the numerous characteristic abactinal straight pedicellariae there is usually an abundance of crossed, distributed as in *antarctica*; but in a large specimen from St. 92 these are relatively few. The crossed pedicellariae are broader than in *antarctica*. In the latter species, the rounded end of jaw is 0.26–0.30 mm. broad while in *studer*i it measures 0.35–0.38 mm. In typical *studer*i the abactinal spinelets are decidedly slenderer and generally obviously more numerous than in *antarctica*. The actinal papular areas contain 2–4 papulae while in large *antarctica* there is only 1. As in *antarctica*, in the ventrolateral combs there are 3 or 4 (rarely 5) prominent spines, of which the inner belongs to an actinal plate.

In medium-sized specimens (R 50 mm.) the straight pedicellariae are confined to side of rays, only a very few occurring on the adambulacral furrow face. From Sts. WS 91 and WS 92 are 2 series illustrating growth stages from R 11 mm. to R 100 mm. One can be reasonably sure that these are all of one species. Up to R 30 mm. there are no straight pedicellariae; or at base of ray only 1 or 2 of a broadly lanceolate form such as is found in *antarctica* and *pedicellaris*.

Without the accompanying adults these small examples would undoubtedly be classified as *antarctica*, although their abactinal spinelets are more numerous and the crossed pedicellariae very much less numerous than in typical small *antarctica*.

The abactinal skeleton is well developed with numerous small irregular meshes. In young specimens the skeleton is rather stronger and the meshes smaller than in corresponding sizes of *antarctica*. The species therefore is in no wise closely related to *Lysasterias perrieri* or to other species having a degenerated dorsal skeleton. Koehler who examined and photographed the type rather unaccountably placed it in his "*Anasterias*", which led me to list it as *Lysasterias* (1930, p. 236). It is, as a matter of fact, very close to *A. antarctica* and possibly may regularly intergrade with that species at intermediate depths. There certainly is no occasion to make the species the type of a new genus on account of its pedicellariae, as Koehler thought might be necessary.

Typical specimens of *studer*i are found in deeper water than *antarctica*. The specimens from St. WS 847, 51 to 84 fathoms, are not typical in having fewer and coarser abactinal spines and fewer straight pedicellariae which, in one specimen, are narrower than in the typical form. The very numerous crossed pedicellariae are of the broader type, and actinal papulae 2 or 3 to an area. One of the 3 specimens is the largest, having R 110 mm.

A large specimen (St. 92, 8 April 1927) is carrying a coalesced mass of eggs 20 mm. in diameter. Each egg is 2.5 mm. in diameter.

TYPE LOCALITY. Falkland Islands, 320 m.

Anasterias pedicellaris (Koehler)

(Plate XIX, fig. 3)

Sporasterias pedicellaris Koehler, 1923, p. 18, pl. 5, figs. 1-6; pl. 6, figs. 1-5, 7-10.*Sporasterias antarctica* Koehler, 1920, p. 78, pl. 18, fig. 4.*Anasterias pedicellaris* Fisher, 1930; p. 225; 1931, p. 8.

St. 55. Port Stanley, East Falkland Island, 10-16 m., 2 specimens.

St. WS 81. 8 miles north, 11° W of North Island, West Falkland Island, 81-82 m., sand, 10 specimens.

St. WS 84. 7½ miles south, 9° W of Sea Lion Island, East Falkland Island, 75-74 m., shells and stones, 13 specimens.

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 14 specimens.

St. WS 221. Off Argentina, 48° 23' S, 65° 10' W, 76-91 m., 1 specimen.

St. WS 576. 51° 35' S, 57° 50' W, 34-24 m., 1 specimen.

St. WS 823. 52° 14½' S, 60° 01' W, 80-95 m., 1 specimen.

Koehler has described in detail this form which is very variable in respect to the robustness of skeleton and the number of both sorts of pedicellariae. The rays are longer and narrower than in *antarctica*, the abactinal skeleton usually weaker, the abactinal spinelets more delicate (and sometimes much more numerous) and the crossed pedicellariae (of about the same size) less numerous. In typical *antarctica* the superomarginal spines are surrounded by numerous crossed pedicellariae, but in *pedicellaris* as in *studerii* these are scarce or absent on the proximal half of ray. The characteristic lanceolate straight pedicellariae are found abundantly only in large specimens; in small ones they are scarce or absent. In general, such small specimens differ from small *antarctica* in having more numerous abactinal spinelets, with not many more crossed pedicellariae than spinelets scattered over the abactinal surface. Without accompanying adults it is questionable if one can be certain of the identification of these young.

A characteristic feature of the species is the variability of the abactinal skeleton, already described and figured by Koehler. When at its weakest it is no better developed than in the type specimen of Perrier's *Anasterias minuta* (see Koehler, 1923, pl. 5, fig. 5). But I am not sure that Koehler's pl. 6, figs. 3 and 10 are not *minuta* rather than *pedicellaris*. They are quite unlike young *pedicellaris* from St. WS 85, at which typical adults were taken. These young have narrow convex rays with a reticulate skeleton and numerous delicate spinelets. But adults may have a skeleton obviously weaker than in typical "*Sporasterias*" (Koehler, pl. 5, fig. 1). I have such specimens from St. WS 85. It is futile therefore to base genera upon the "more or less" development of the abactinal skeleton, where one species exhibits such instability.

The integument is soft and rather thick but not pustulated in the ordinary sense. The abactinal, intermarginal, and actinal pedicellariae are large, the last usually 2 or 3 to an area.

This seems to be a shallow water form, whereas *studerii* is found in much deeper water and differs *inter alia* in having shorter and broader, more triangular, straight pedicellariae.

DISTRIBUTION. Tierra de Fuego, Falkland Islands, north to 48° 23' S, 7-95 m.

Anasterias minuta Perrier

(Plate XIX, fig. 4)

Anasterias minuta Perrier, 1875, p. 81; 1891, p. 93 (in part).—Fisher, 1930, p. 223; 1931, p. 6, pl. 6, pl. 7, figs. 1, 2.

?*Asteroderma papillosum* Perrier, *Comptes Rendus*, cv1, 1888, p. 765; 1891, p. 96.

?*Asterias minuta* var. *Asteroderma papillosum* Perrier, 1891, pl. 10, figs. 3a-3c.

Sporasterias pedicellaris, part, Koehler, 1923, p. 18.

St. 53. Port Stanley, East Falkland Island, 0-3 m., 4 specimens.

St. 55. Entrance to Port Stanley, East Falkland Island, 10-16 m., 7 specimens.

St. 58. Port Stanley, East Falkland Island, 1-2 m., 1 specimen.

The specimens range in size from R 8 mm., r 4 mm. to R 37 mm., r 10 mm. All have a thick pulpy skin which is subdivided into small unequal areas by deep creases. These soft cushions of skin are not essentially different from the more inflated "pustules" of the skin of *Lysasterias perrieri* which the specimens somewhat resemble.

The abactinal surface has a very few scattered small spinelets and crossed pedicellariae placed here and there, but these, as well as the underlying skeleton, are completely hidden unless dried. Only a few superomarginal spinelets are present as rudiments here and there, but a double series of well-developed inferomarginal spines occurs on the ventrolateral border of ray. Between these and the single series of adambulacrals is a longiseries of large single papulae. Intermarginally there are very large papulae, 2 or 3 to an area, and a series of large ones above the superomarginal plates, but on the rest of the abactinal area they are difficult to differentiate from the pustules. On the abactinal plates interradially, on the superomarginals, inferomarginals, along actinal groove, and on furrow face of the adambulacrals is a quite variable number of conspicuous, elongate, stout, lanceolate straight pedicellariae. Only a very few crossed pedicellariae are scattered on the marginals. In the smallest specimen there is a superomarginal spinelet to each plate, and to each ray about 12 abactinal spinelets, which are definitely longer than the crossed pedicellariae, papulae, and intervening folds of skin. There are no actinal papulae as yet, but large intermarginal ones are present. This specimen has about the same spine development as the type specimen.

The abactinal skeleton is weak and incomplete, but there is variation in the incompleteness. In a specimen having R 24 mm. it consists of a short tongue of 1-3 small ossicles extending mesially from the dorsal lobe of each superomarginal. Between these 2 lateral series are unevenly scattered independent plates, or 2 or 3 in series disconnected from the rest. The vestiges of the carinal series are present on outer half of ray. Such a skeleton is obviously identical with what is found in some specimens of *Lysasterias*. Another specimen of *minuta* has a wide meshed skeleton of slender ossicles consisting chiefly of carinal plates and complete or interrupted sinuous transverse series which extend mesially from the superomarginals. On the distal half of ray, the skeleton is less connected than proximally. This specimen represents the condition of skeleton of the type specimen, of which mention has been made under the genus.

So far as the essential structure of skeleton is concerned this species completely bridges the gap between *Anasterias* and *Lysasterias*.

The type of *A. minuta* is in the Museum d'Histoire Naturelle (E 792 Hombron et Jacquinet, 1847, alcohol). Perrier considered the type locality to be Port Famine, Magellan Strait, and hence probably from very shallow water.

I have also studied 2 dried specimens from Darwin Harbour, Choiseul Sound, Falkland Islands (No. 2623 Museum of Comparative Zoology). The smaller measures R 18 mm., r 6 mm.; the larger R 48 mm., r 13 mm. In the smaller example the abactinal skeleton is clearly visible and consists of a weak, irregular reticulum resembling the condition of *A. pedicellaris* as figured by Koehler (1923, pl. 5, figs. 1, 4) and closely similar to that of the type specimen of *minuta*. Most of the superomarginals carry one spinelet and the inferomarginals two, while scattered along the intermarginal channel and inside the furrow margin are rather numerous, lanceolate, straight pedicellariae two-thirds the length of the superomarginal spinelets. In the larger specimen, however, the abactinal integument is thickened and conceals the skeleton, which is quite weak and irregular as in Koehler's pl. 5, fig. 1, alluded to above. The proportions are about as in fig. 4. There are a few actinal plates and spines at the base of the ray and the adoral carina is composed of 3 pairs of contiguous adambulacrals, the first pair larger than second, and the second larger than third. The superomarginal spines have been mostly absorbed; pedicellariae as in the small example. A third specimen (no. 2624) carries a cluster of young.

In the United States National Museum are 25 specimens from Port Stanley collected by Dr W. L. Schmitt (Fisher, 1931, p. 7).

None of the young of *pedicellaris* (accompanied by adults) which I have examined exhibit such a degeneration of skeleton as is shown in Koehler's figures (1923, pl. 5, fig. 5; pl. 6, figs. 3, 10). The specimens which I feel fairly certain are young stages of the adults called *pedicellaris* have narrow rays, numerous abactinal spinelets, a small meshed, complete abactinal skeleton, and a thinner skin lacking pustules. Lanceolate pedicellariae small, few or lacking.

But one specimen of *minuta* (R 31 mm.) from St. 55 has more numerous abactinal spinelets and thinner skin than the others, and at the same time differs from an example of *pedicellaris* (R 36 mm.) from the same station in having a weaker skeleton, much fewer straight and crossed pedicellariae.

The explanation of the confusion may be that *minuta* is the not fully grown stage of a weak-skeleton forma of *pedicellaris* such as Koehler's pl. 5, fig. 1, from West Point Island, West Falkland. This form would usually have few abactinal spinelets and few crossed pedicellariae, but numerous straight pedicellariae. The other extreme would be represented by the multispinous young and adults with a close-knit complete abactinal skeleton and usually abundant crossed pedicellariae, but with very few straight ones when R is less than 25 mm.

So far as *skeleton* is concerned the varieties of such a polymorphic species would fall in *Sporasterias*, *Anasterias* and *Lysasterias*!

Anasterias conferta (Koehler)

(Plate XIX, fig. 5)

Kalyptasterias conferta Koehler, 1923, p. 43, pl. 4, figs. 1-7.—Fisher, 1930, p. 234.

Anasterias conferta Fisher, 1931, p. 9.

St. 53. Port Stanley, East Falkland Island, 0-2 m., 19 specimens.

Koehler gives good figures of alcoholic and dried specimens which are probably adult, as R varies from 60 to 70 mm. They were taken in 4-7 m. at Port Louis, Falkland Islands.

The Discovery specimens range in size from R 4.5 mm. to R 34 mm. The larger agree with Koehler's figures. The small ones closely resemble specimens of *A. minuta* but, generally speaking, have a more arched disk and more convex rays which taper from a broader base. The straight pedicellariae are few and smaller.

The abactinal skeleton consists of a weak, very irregular and open reticulum in which the small carinals form a sinuous interrupted series much weaker than in the type of *A. stolidota*. The superomarginals are well developed, imbricate strongly and usually carry a small spinelet. There is, however, great variability in these features. In a specimen which I reported (1931, p. 9) from Teal Inlet, Falkland Islands, the abactinal plates have degenerated so that they are entirely disconnected. The skeleton is represented by scattered small circular and slender elongate ossicles. Similarly, the marginal plates are reduced in size, the spineless superomarginals forming a slender sinuous longiseries as in the type of *Kalyptasterias conferta*.

Koehler (1923, p. 46) was handicapped by lack of knowledge of the skeleton of *Calvasterias stolidota* Sladen, which greatly resembles *conferta*. It may be stated that *stolidota* is not a *Calvasterias* but is an *Anasterias* closely related to *conferta*. The two may be forms of the same species. The small specimen of *stolidota* recorded by Sladen (1889, p. 591) from Port William is probably referable to *conferta*.

The type of *stolidota* measures R 44 mm. and is from the Messier Channel between Wellington Island and the west coast of Chili. In 1928 the late Mr G. A. Smith of the British Museum (Natural History) made for me photographs of the skeleton of a ray, which I think will serve a very useful purpose in the present connection (Pl. XIX, fig. 6).

As will be seen the skeleton is of the reticulate type with strong imbricating carinals and stout spiniferous superomarginals. The dorsolateral mesh consists of normally developed plates. The whole might illustrate *A. antarctica* or *A. studeri*.

Genus *Lysasterias* Fisher

Lysasterias Fisher, *Smithsonian Miscell. Coll.*, LII, May 1908, p. 88; *Zool. Anz.*, XXXIII, August 1908, p. 356. Type *Anasterias perrieri* Studer, 1885, but not Perrier, 1891.—Fisher, 1922, p. 594; 1923, p. 606; 1926, p. 197; 1930, p. 235.

Anasterias Ludwig, 1903, p. 42.—Koehler, 1906, p. 12; 1908, p. 566; 1912, p. 10; 1920, p. 11; 1923, p. 11.—Verrill, 1914, p. 354.—Not *Anasterias* Perrier, 1875; not *Asteroderma* Perrier, 1875.

Paedasterias Verrill, 1914, p. 355. Type *Anasterias chirophora* Ludwig.—Koehler, 1920, pp. 16, 30.

DIAGNOSIS. Differing from *Anasterias* in a further reduction of the abactinal and marginal skeleton, which in its poorest development consists of lateral transverse tongues of plates (composed of two reduced marginals plus one to several abactinal elements) abutting on the adambulacral plates; dorsal surface with much reduced, disconnected, scattered platelets, or a sketchy rudimentary reticulum (principally on disk); or, especially in mature specimens, no plates; integument thick, raised in mammillated pustules which represent elaborated spine sheaths; adambulacral plates monacanthid; no actinal spines, the actinal plates rudimentary, confined to disk, or present as an inconspicuous series crowded between the inferomarginals and adambulacrals; gonads open ventrally—paedophoric.

REMARKS. This is the *Anasterias* of most authors. It is closely related to true *Anasterias* and differs chiefly in the development of the spine sheaths into glandular pustules (probably *pari pasu* with the disappearance of spines and dorsal plates) and in the disappearance of functional actinal plates. Various degrees of degeneration of the dorsal and marginal skeleton are met with in the type species, *perrieri*. In some varieties the abactinal skeleton is as well developed as in *Anasterias*; in others it is practically absent. There is direct evidence in specimens of *perrieri* from South Georgia that there is a gradual degeneration of abactinal and marginal skeleton as the animal grows, as if the calcium were required for the growth of the more important axial skeleton and essential spines (i.e. the actinostomial ring, the ambulacral and adambulacral systems). In this graded series the abactinal skeleton disappears with increasing age while the marginal plates shrink in size, change their shape, and certain superomarginal connectives disappear entirely.

Verrill's genus *Paedasterias* was founded pretty largely upon an erroneous translation. Ludwig (1903, p. 42), in a synopsis of "*Anasterias*", says: "Die Spagen haben (mit Ausnahme der Armspitze) *keinen oberen Randstachel*; grosse Tatzepedicellarien vorhanden. . . . *An. chiophora* n.sp." Verrill diagnoses the genus: ". . . the upper marginal plates being absent except as rudiments distally". But Ludwig in a major division of his synopsis states that the upper marginal plates are present in *chiophora*. Koehler (1920, p. 30) adopted *Paedasterias*, and added a new species, *joffrei*. As a matter of observation it may be stated that there are reduced superomarginal plates in the species supposed to lack them and that there is no valid generic hiatus between the forms with reduced marginals and those having well-developed marginal plates and spines, such as *adeliae* and *perrieri*. In fact the new species described below, *L. hemiora*, with greatly reduced marginals, may turn out to be a variant of *perrieri*, incredible as it now appears.

Lysasterias is pretty much a genus of convenience. It appears to be an Antarctic offshoot of *Anasterias* which has suffered, along with *Perknaster* and some other genera, a grave disturbance of calcium metabolism.

Lysasterias perrieri (Studer)

Anasterias perrieri Studer, Die Seesterne Süd Georgiens, *Jahrb. wiss. Anst. Hamburg*, 11, 1885, p. 153.—Koehler, 1920, p. 17.

Anasterias tenera Koehler, 1906, p. 12, pl. 2, figs. 11–16; pl. 3, figs. 27, 28; pl. 4, fig. 41; 1908, p. 569; 1912, p. 10; 1920, pp. 11, 17, pl. 2, figs. 1–4, 10; 1923, p. 11.

Anasterias cupulifera Koehler, 1908, p. 566, pl. 5, fig. 52; pl. 6, figs. 58, 59; 1920, p. 16.

Anasterias lysasteria Verrill, 1914, p. 354 (unnecessary substitute name; see Fisher, 1922, p. 593).

?*Anasterias Studeri* Koehler, *Sci. Bull. Brooklyn Inst. Arts and Sci.*, 11, no. 4, 5 November 1914, p. 61, very young.

Anasteria Victoriae Koehler, 1920, p. 17, pl. 2, fig. 5; pl. 3, figs. 1–6; pl. 4, figs. 1–4; pl. 5, figs. 1–10; pl. 6, figs. 1–4; pl. 57, fig. 1; 1923, p. 12.

Lysasterias perrieri Fisher, 1930, p. 236.

Lysasteris cupulifera Fisher, 1930, p. 236.

Lysasterias tenera Fisher, 1930, p. 236.

Lysasterias victoriae Fisher, 1930, p. 237.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122–136 m., green mud and stones, 1 specimen.

St. 141. East Cumberland Bay, South Georgia, 17–27 m., 1 specimen.

St. 145. Stromness Harbour, South Georgia, 26–35 m., 23 specimens.

St. 156. South Georgia, 53° 51' S, 36° 21' 30" W, 200–236 m., rock, 1 specimen.

St. 159. South Georgia, 53° 52' 30" S, 36° 08' W, 160 m., rock, 11 specimens.

St. 164. East end of Normannia Strait, South Orkneys, near Cape Hansen, Coronation Island, 24–36 m., 1 specimen.

St. 170. Off Cape Bowles, Clarence Island, 61° 25' 30" S, 53° 46' W, 342 m., rock, 4 specimens.

St. 175. Bransfield Strait, South Shetlands, 63° 17' 20" S, 59° 48' 15" W, 200 m., mud, stones, gravel, 1 specimen.

St. 456. 1 mile east of Bouvet Island, 40–45 m., 3 specimens.

St. 1873. Off Clarence Island, 61° 20' 8" S, 54° 04' 2" W, 200–137 m., 18 specimens.

St. 1941. Leith Harbour, South Georgia, 55–22 m., 8 specimens.

St. 1959. Scotia Bay Anchorage, South Orkneys, 5 m. (fish trap), 1 specimen.

St. WS 25. Undine Harbour (North) South Georgia, 18–27 m., mud, sand, 1 specimen.

St. WS 62. Wilson Harbour, South Georgia, 15–45 m., 1 specimen.

St. MS 6. East Cumberland Bay, South Georgia, 27 m., 4 specimens.

St. MS 10. Same, 26 m., 1 specimen.

St. MS 62. Same, 31–40 m., 1 specimen.

St. MS 63. Same, 23 m., 1 specimen.

St. MS 67. Same, 38 m., 3 specimens.

St. MS 68. Same, 220–247 m., 1 specimen.

Cumberland Bay, South Georgia, 2 specimens.

Numerous figures and detailed descriptions of this polymorphic species are given by Koehler (1906, 1920, 1923). It is fairly common at South Georgia in shallow and moderate depths, and it is therefore not strange that it was encountered by early collectors and was the first species of the genus to be described. I have no doubt whatever that Studer's species is the same as that recorded by Koehler in 1923 as *tenera* and *victoriae*. The dispersed abactinal straight pedicellariae characteristic of some specimens are mentioned by Studer.

In the same haul I find representatives of Koehler's two species, which are based largely upon the presence or absence of straight pedicellariae on the dorsal surface. This is a character subject to great individual variation. If there are actinal or intermarginal straight pedicellariae but no abactinal in some specimens, certain others are sure to have few or many in addition on the abactinal surface. An "infection" of straight pedicellariae is sure to spread. The alleged difference in the width of the intermarginal channel proximally simply does not hold up. Specimens with abactinal pedicellariae and a good development of abactinal skeleton will also have as broad a channel as those with no abactinal skeleton on rays, and no abactinal straight pedicellariae. The size of the marginal plates varies with age and also with locality.

In fact, local varieties are the rule rather than otherwise with this species. There is a tendency in some localities for the spines to be resorbed with increasing age, and this is accompanied by a resorption of plates—first the abactinal, then the superomarginal. Koehler notes as a "curious circumstance" that in South Orkney specimens the lateral spinelets are better marked and more constant in small than in large individuals. The same effect can be seen in the growth series from St. 145. It is apparently normal in some localities but much less marked in others where the superomarginal plates are less reduced in size and the series of spines more perfect.

The degree of development of abactinal skeleton varies with locality and age. It ranges from a skeleton similar to that of *Anasterias minuta* through a condition of scattered plates to no plates on rays and only a feeble ring of them on the disk. The size and shape of the abactinal pustules is also very variable. *L. cupulifera* (Koehler), South Orkneys, seems to me nothing more than an individual variation of *perrieri*, some of its peculiarities due to accidents of preservation.

The range of variation in the specimens included in the above list of localities is no whit greater than is generally accepted for *Diplasterias brandti*. In fact, one variation is analogous, namely a dispersal of pedicellariae between spinelets (or their residuary pustules) in contrast to a localization around spinelets.

Koehler (1923, p. 12) records *L. victoriae* from Port Louis, Falkland Islands. I believe this to be an error of label or of identification; if the latter, the specimen might conceivably be an *Anasterias pedicellaris* with an unusually weak dorsal skeleton. If a well-developed series of actinal plates and a certain number of actinal spines are present, it is *pedicellaris*. The specimen was dry.

The largest specimen in the Discovery collection is from St. 164 and measure R 117 mm., r 23 mm., br 25 mm. One series of superomarginals and 2 series of inferomarginal spines are well developed. A few small carinal spinelets immersed in their compound pustules survive at base of ray. The pustules are unequal, small, very numerous. The specimen is labelled "cream buff with orange ova". The specimen from St. 1959, Scotia Bay, South Orkneys, R 85 mm. is almost identical in appearance and is labelled: "Dorsal surface very rich, deep, creamy yellow, pale yellow below."

Something in the environment of East Cumberland Bay, South Georgia, seems to be detrimental to skeletons, as the large specimens (R 90–95 mm.) from here are very

flaccid, the marginals small, and the marginal spines are soft as if undergoing resorption. Many have already disappeared.

The 23 specimens from St. 145, Stromness Harbour, South Georgia, form a well-graded series from R 10 mm. to R 80 mm. and are typical in having very little in the way of an abactinal skeleton. The body wall of a specimen with R 32 mm. and one with R 80 mm. was cleared. In the former there are indications of a meandering, interrupted carinal series, with parts of an interrupted net on either side; and from the dorsal lobe of the superomarginal plates, 0-3 small ossicles form (when present) a transversely oriented bar. The superomarginals are articulated *in series by 1 or 2 oblong intermediate ossicles* while the inferomarginals imbricate by their lobes. At base of ray are a few very small actinal ossicles wedged between the inferomarginals and adambulacrals. Abactinal spinelets are few, the numerous pustules containing a single crossed or a larger lanceolate straight pedicellaria. In the larger specimen, the abactinal system is reduced to widely separated grains, bearing small spinelets, in the radial area; the *supramarginal* tongues of plates have mostly disappeared, *as have the superomarginal connectives*. The spineless actinals have advanced beyond middle of ray, but only the proximal are of significant size. The very numerous abactinal pustules contain mostly single straight pedicellariae with a scattering of crossed; the voluminous superomarginal and inferomarginal compound cup-shaped pustules contain mostly crossed, with a few slightly larger straight, but with conspicuously larger straight ones in the narrow actinal channel. The greatest variation exists in the number of straight pedicellariae and it is futile to base even a forma on their presence, much less to invoke them as a specific character (for *victoriae*). Both "species" can be formed in this growth series.

The series from St. 1873 (Clarence Island), however, is notable for having, in the random samples which were dried or cleaned, only crossed pedicellariae, except for a series of straight ones on furrow margin. Moreover, the abactinal plates form a loose, weak, wide-meshed incomplete reticulum on the median or radial region of ray. In some specimens there are numerous slender abactinal spinelets surrounded by a stole of pedicellariae, while in others the spinelets are very few and the circular or polygonal stole becomes a compound pustule or cupule filled with pedicellariae. In general the smaller specimens have the best spine development. Size limits R 15 mm. to R 60 mm. Although this form lacks abactinal and marginal straight pedicellariae it differs from the typical forma *tenera* of Koehler (1906) from Booth Wandell Island in having a better developed abactinal skeleton and spinelets. However, Koehler's specimens ranged from R 65 mm. to R 120 mm. and the spines and skeleton may have been resorbed.

A modification of the above form is found in specimens from Sts. 170 and 175 in which there is about the same development of abactinal skeleton and spinelets but the crossed pedicellariae are mostly scattered thickly over the abactinal surface, only 1 or 2 being attached to the spinelets. The pustules are weakly developed. The single superomarginal and double inferomarginal spines have numerous associated crossed pedicellariae. The specimens from St. 456, Bouvet Island, are a variety of this form, poorer in pedicellariae. The largest example (R 50 mm.) resembles Koehler's figure of *tenera* (1906).

TYPE LOCALITY. South Georgia.

DISTRIBUTION. Probably circumpolar: South Orkneys, South Shetlands, Graham Coast; latitude 64° to 67° S and longitude 92° to 145° E; north to Bouvet Island and South Georgia. Shallow water to 647 m.

Lysasterias adeliae (Koehler)

Anasterias adeliae Koehler, 1920, p. 26, pl. 1, figs. 1, 2, 5-10; pl. 56, fig. 1.

Lysasterias adeliae Fisher, 1930, p. 236.

St. 181. Schollaert Channel, Palmer Archipelago, $64^{\circ} 20' S$, $63^{\circ} 01' W$, 160-335 m., mud, 1 specimen.

Koehler's 2 specimens were taken in 12 fathoms, Adélie Land. The largest measured R 38 to 44 mm., r 10 mm. The present specimen measures R 65 mm., r 12 mm., br 13 mm. The rays are decidedly longer and more attenuate distally, and ray tip more pointed than in Koehler's illustrations. It differs also in having rather numerous, conspicuous abactinal straight pedicellariae which are narrowly lanceolate, acute.

The marginal plates are as well developed as in *perrieri* and the intermarginal channel is broad proximally. The superomarginal plates soon become disconnected and spaced from one another. There is a definite series of superomarginal and one of inferomarginal spines. Attached to the cupule-like sheaths are from 1 to 5 large crossed pedicellariae (0.9-1 mm. long), and on the inferomarginals also several small ones, hardly half as long together with one to several lanceolate straight pedicellariae. The abactinal crossed pedicellariae seem to be only of the small size—not large and small mixed as I infer to be the case in *L. belgicae* (Ludwig). The roundish or lobed abactinal plates of the rays are mostly isolated, widely spaced, and carry usually an acicular spinelet. On the disk is an irregular ring of connected plates, which includes (at mid-r) a large madreporite, and carries about 30 spaced spinelets. Within the circle are about 10 spinelets springing from mostly isolated plates.

Although this specimen is not typical I have little hesitation in referring it to *adeliae*. The extension to abactinal area of the straight pedicellariae is an item of scarcely varietal importance as this is a matter in which the Asteriidae exhibit very wide individual variation.

L. adeliae differs from *perrieri* chiefly in the disparity in size of the abactinal and marginal pedicellariae. *L. belgicae* has both large and small crossed pedicellariae, but Ludwig does not state that the large size is marginal only. *Belgicae* has very small marginal plates and therefore would seem to be more nearly related to *joffrei* than to *adeliae*. In *joffrei* the inferomarginal crossed pedicellariae are also abruptly larger than the abactinal.

Adélie Land and Palmer Archipelago are the only known records for this species. Bathymetric range 22-335 m.

Lysasterias joffrei (Koehler)

Paedasterias joffrei Koehler, 1920, p. 30, pl. 1, figs. 3, 4, 9; pl. 2, figs. 7, 8, 9; pl. 56, fig. 2.

Lysasterias joffrei Fisher, 1930, p. 236.

St. 1660. Ross Sea, $74^{\circ} 46.4' S$, $178^{\circ} 23.4' E$, 351 m., 1 specimen.

St. 1957. Off south side Clarence Island, South Shetlands, 785–810 m., 1 specimen.

Koehler's only specimen, having R 80–85 mm., r 13 mm., was taken in 354 fathoms in D'Urville Sea, off Adélie Land ($66^{\circ} 50' S$, $142^{\circ} 06' E$). The specimen from St. 1660 measures R 53 mm., r 8–9 mm., br 10 mm. The rays are narrow, evenly tapered and high arched, being as high at base as width.

This species and *chirophora* are notable for the great reduction of the marginal plates. I examined a portion of the body wall at base of the ray. The inferomarginals are very small, much longer than high as seen from the coelomic side and touch end to end. A small ovate or elliptical superomarginal is imbricated to the upper lobe of each inferomarginal, and therefore widely separated one from another. There are no superomarginal spinelets except 2 or 3 very small ones at tip of ray. The series of superomarginal sheaths or pustules can, however, be traced to base of ray as they are a little larger than the superjacent abactinal pustules. The inferomarginal spines are single and the thick compound sheaths with numerous large crossed pedicellariae press against the upright adambulacral spines.

The conspicuous pedunculate straight pedicellariae (1.4 mm. long) which Koehler names "en palette" are only slightly different from ordinary lanceolate ones, the jaws being more oblong than tapered, with rounded ends without conspicuous teeth. Occasionally they resemble a very narrow turtle's head in miniature. They are somewhat more widely distributed than in the type for, in addition to being fairly numerous on the abactinal area and sides of rays, they occur also in the actinal interradiial areas, on the mouth-plates, and furrow face of the first few adambulacrals, being succeeded on the remainder by conspicuously smaller ones not greatly different in shape.

In this specimen the inferomarginal crossed pedicellariae are larger than the abactinal and are the same size as in type (1 mm. long).

The small specimen, St. 1957, R about 24 mm., r 6 mm., is placed here with some misgivings. The marginal plates, still fairly robust, seem to be undergoing degeneration. In the arm axils are 1 or 2 conspicuous spatulate pedicellariae without teeth.

Lysasterias hemiora sp.nov.

(Fig. L, 3; Plate XX, fig. 2)

DIAGNOSIS. In general appearance resembling a narrow-rayed *L. perrieri* but lacking a series of superomarginal spinelets or of substitute differentiated pustules, the small roundish abactinal pustules appearing to extend right up to the abruptly larger inferomarginal spines and their enclosing sheaths. R 66 mm., r 13 mm., br 13 mm., height of ray at base 12 mm.; ray narrow, very gradually tapered to bluntly pointed extremity,

high arched, the inferomarginals, close to the single adambulacrals, defining border of the subplane actinal surface.

DESCRIPTION. The abactinal and lateral pustules are very small and numerous, closer together than the space between. Nearly all of them enclose a small crossed pedicellaria of one size, 35–38 mm. in length. The lowermost series of these small pustules represents the superomarginals. At end of ray the last 1 or 2 pustules have a tiny central spinelet. These are probably resorbed and the material used in the next distal plate to be formed. The proximal 6–12 slender inferomarginal plates carry 1 spinelet, the remainder 2. They measure 2.25–2.75 mm. in length and their sheaths contain a few crossed pedicellariae 0.33–0.45 mm. long, and a lanceolate straight pedicellaria 0.5 mm. long.

The abactinal skeleton of rays is reduced to tiny scattered plates sometimes carrying a tiny spinelet. The antiambulacral bars have 3 or 2 plates proximally and are opposite every fourth or fifth adambulacral. The small inferomarginal elements are slightly separated in the sample examined.

The papulae of disk and proximal half of ray are in numerous groups of 2 or 3; distally they are mostly single. The actinal channel is smooth, soft, and crossed by transverse furrows between inferomarginal plates.

Along furrow margin, from mouth-plates, is a series of pedunculate straight pedicellariae with narrow round-tipped valves; length *circa* 0.6–0.7 mm.

In the actinal interradi al channel can be seen 2 gonopores. In the interbrachial channel are a few small pedunculate straight pedicellariae.

TYPE LOCALITY. St. 189. Port Lockroy, Weincke Island, Palmer Archipelago, 70 m., 1 specimen.

REMARKS. This species, if species it is, belongs to the section of the genus with much reduced marginal plates, wherein the marginal or antiambulacral skeleton consists of a series of spaced transverse bars along the side of ray. In this species there are two or three pieces to each bar, the third, when present, representing an abactinal element. In young examples one would expect to find 5, 6 or even more plates, perhaps connecting up with an incomplete or sketchily outlined abactinal reticulum.

L. hemiora differs from other species belonging in this group, namely *chirophora*, *lactea*, *belgicae*, *joffrei* in lacking differentiated superomarginal pustules, or spines, and in having crossed pedicellariae of one general size. If *chirophora* has varieties lacking the broad unguiculate straight pedicellariae, the crossed should nevertheless appear in two sizes, namely, 0.6–0.9 mm. for the larger and 0.3–0.37 mm. for the smaller. In *L. belgicae* the two sizes are 0.9–1.17 and 0.4 mm. In *lactea* the inferomarginal and lateral crossed pedicellariae measure 0.65–0.73 mm., the dorsal slightly less; while the representatives of the small sort, described as numerous, are only 0.2–0.22 mm. long. The only known specimen of *lactea* has well-differentiated superomarginal spines.

When all this is said, the remote possibility remains that *hemiora* may represent a freakish sort of mutation of the variable *perrieri*.

Lysasterias heteractis sp. nov.

(Fig. L, 4-4b; Plate XX, fig. 1)

DIAGNOSIS. Resembling a specimen of *L. perrieri* having 8 slender rays. R 87 mm., r 20 mm., br 16 mm., R = 4r plus.

DESCRIPTION. Abactinal surface with very numerous small pustules of unequal size, enclosing a delicate terete spinelet and 2 or 3 small crossed pedicellariae, or the latter only. These pustules are irregular in outline and separated by narrow grooves except on central area of disk where they are spaced, and the puffy skin can be seen between them. Numerous small papulae, most conspicuous in the interbrachial channels. Spinelets range from 1 to 1.7 mm. long by 0.25 mm. thick at base, and the tip is minutely thorny. The pedicellariae are 0.45-0.55 mm. long, the tip broad and bluntly rounded. In profile the outside of terminal lip is long.

The abactinal skeleton is represented by irregularly and widely scattered separate small plates, or sinuous lines of them suggesting a degenerate reticulation. On side of ray the marginal plates (plus 1 or 2 small abactinals proximally) form weak oblique costae opposite, on an average, every fourth ambulacral. The inferomarginals touch one another proximally but are separated distally. The superomarginals are transversely elongate and do not touch one another.

On sides of ray are 2 series of much larger marginal pustules. Superomarginal spinelets (2.5-3.5 mm.) abruptly longer than abactinal, generally 1 to a pustule but occasionally 2 at base of ray, and surrounded by about 5 crossed pedicellariae larger than the abactinal (0.75-0.85 mm.). Inferomarginal spinelets slightly thicker than superomarginal, 2 at base of ray and 1 on outer half or two-thirds, accompanied by 5-8 crossed pedicellariae similar to the superomarginal. Sometimes each proximal inferomarginal spine is surrounded by its own pustule so that there are three in a vertical series. There are a very few inconspicuous small lanceolate marginal pedicellariae.

The adambulacral spines are slender, rather long (3-3.5 mm.), close-set, and one to a plate. The narrow space between them and the inferomarginal spines is devoid of papulae although intermarginal papulae are present. The swollen inferomarginal pustules usually abut on the upright adambulacral spines.

The mouth angle is constricted, about 4 pairs of adambulacrals behind the oral plates being in contact. The small oral plates have 4 spines on the actinostomial border of each angle, and close behind these a pair of longer suborals exactly like the following adambulacrals. On the mouth-plate and along the furrow face of the adambulacrals are simple lanceolate straight pedicellariae (sometimes with one valve tip hooked over the other) averaging 0.7 mm. long by 0.38 mm. broad at base.

The madreporite is circular, 3.5 mm. in diameter, and situated at mid-r.

The ambulacral furrow is wide, the tube-feet numerous and crowded. One can sometimes count 5 in a transverse series.

The gonads (testes) are attached to the interbrachial septum 5 mm. from the interbrachial sulcus on a level with the intermarginal line. The duct opens at the tip of

a papilla (there being a pair close together) in each constricted actinal interradiar area.

TYPE LOCALITY. St. 170. Off Cape Bowles, Clarence Island, 342 m., rock, 1 specimen.

Genus *Diplasterias* Perrier

Diplasterias Perrier, *Comptes-rendus*, CVI, no. 11, 1888, p. 765; 1891, p. 77. Type *Diplasterias lütkeni* Perrier.—Fisher, *Smithsonian Miscell. Coll.*, LII, 1908, p. 89 (error in assignment of *sulcifera* as type); 1930, p. 229.

Podasterias Perrier, 1894, pp. 107, 108; 1896, p. 35. Type *Diplasterias lütkeni* Perrier (not *Podasterias* Perrier, 1891, p. 160).—Fisher, 1923, p. 603; *Zool. Anz.*, XXXIII, 1908, p. 358.

Koehleraster Fisher, 1922, p. 596; 1930, p. 234. Type *Anasterias octoradiata* Koehler.

Bathyasterias Fisher, 1930, p. 231. Type *Asterias vesiculosa* Sladen.

DIAGNOSIS. Adambulacral plates diplacanthid, the spines without attached pedicellariae; abactinal skeleton irregularly reticulate; the plates with one to several slender spines surrounded by a collar of pedicellariae and more or less heavily sheathed with membrane which usually obscures skeleton, or without spines; marginal plates well developed; superomarginal spines 1 or 2, conspicuous, clearly differentiated from abactinal and surrounded by pedicellariae; inferomarginal spines usually 2, sporadically 3, bearing pedicellariae and forming definite longitudinal series separated from superomarginals by a well-defined intermarginal channel; actinal spines with attached pedicellariae, in 1 longiseries (actinals exceptionally spineless); 2–4 pairs of contiguous postoral adambulacral plates; not fissiparous; gonads opening ventrally; young brooded by adult; straight pedicellariae lanceolate, typically not enlarged nor unguiculate. Differing from *Anasterias* in having a stronger abactinal skeleton and diplacanthid adambulacral plates.

REMARKS. In the first reference to *Diplasterias* (1888) Perrier cites *D. lütkeni* Perrier and *D. steineni* Studer as species which brood their young. He adds: "Je classe dans le genre *Diplasterias* les *Asterias* qui ont deux rangées au moins de piquants adambulacraires."

In the Cape Horn report, published three years later, *Diplasterias* is entered as a new genus, with the same diagnosis. Five species are enumerated and described: *D. sulcifera* (Perrier, 1869), *D. loveni* Perrier, *D. lütkeni* Perrier, *D. spinosa* Perrier, *D. steineni* (Studer).

Diplasterias was thus formally published in connection with definite species from which a type may be selected. If the first reference is to be regarded as a *nomen nudum*, as I suggested in 1908 (Fisher, 1908, p. 89), the enumeration of *D. lütkeni* and *D. steineni* is useful as an indication of the species which Perrier had in mind for his new, if somewhat indefinite, genus. While Perrier's Cape Horn report was in the press, Sladen used Perrier's first species, *D. sulcifera*, for the type of *Cosmasterias*. My choice, in 1908, of *D. sulcifera* as the type of *Diplasterias* was ill advised, due to a strict adherence to the "first species rule" for the determination of a type when none is indicated by the author. It seems to me that the oldest known species, *Asterias brandti* Bell, which includes both *Diplasterias lütkeni* and *loveni* (cited by Perrier in 1891) should be chosen, especially as *D. lütkeni* appears in the first, or *Comptes Rendus*, citation.

Diplasterias obviously antedates *Podasterias* Perrier, 1894, even if the generic diagnosis is vague in the light of modern information. *Diplasterias* made no deep impression on Perrier's mind, because he readily abandons it on p. 160 of the Cape Horn paper, in a comment on Sladen's recently published subdivisions of *Asterias*. Here he merges his *Diplasterias* with Sladen's *Asterias*.

On the same page (1891, p. 160) he unfortunately introduces *Podasterias* for the *Asterias sulcifera* group, stating that *Cosmasterias* has priority for this generic division. This is the first occurrence of *Podasterias* in literature. But in 1894,¹ disregarding his *Podasterias* of 1891, he introduced a quite different *Podasterias* for species near *A. lütkeni*. This is precisely synonymous with his *Diplasterias* of 1891, and is the *Podasterias* used by Verrill, Koehler after 1917, and Fisher, 1923. *Podasterias* of 1891 must obviously be discarded for *Cosmasterias*, while that of 1894 had no status when proposed, being a homonym of the first, as well as a synonym of *Diplasterias*.

Disregarding his *Diplasterias* of 1891, Perrier in 1894¹ employs *Diplasterias* in a different sense, namely, for *Asterias* Linnaeus. In this paper the Asteroidea lack a genus *Asterias*.

In 1896² *Podasterias* is preserved for *Diplasterias lütkeni*, *Asterias* is reinstated, and *Diplasterias* discarded entirely.

Ludwig in 1903³ used *Diplasterias* in the sense in which I advocate employing it. Meissner in 1904⁴ employed the name for *Cosmasterias* plus *Diplasterias*. Koehler in 1906, 1908, and 1912, used *Diplasterias* to include also *Cryptasterias* Verrill, 1914. In 1917, and subsequent papers, Koehler adopted *Podasterias* with very nearly the limits I have assigned to *Diplasterias*. In 1914 Verrill⁵ used *Podasterias* for *Diplasterias* but assigned *Asterias brandti* Bell, *A. alba* Bell, *A. neglecta* Bell, and *A. obtusispinosa* Bell to *Cosmasterias*, the last three as possible synonyms of *C. lurida* (Philippi).

In 1930 I placed Studer's *Asterias steineni* along with his *A. georgiana* in a new genus *Neosmilaster*, leaving in *Diplasterias*, *brandti* (Bell), *brucei* (Koehler), *focchi* (Koehler), *kerghuelensis* (Koehler), *meridionalis* (Perrier), and *vesiculosa* (Sladen).

Diplasterias brandti (Bell)

Asterias brandti Bell, 1881, p. 91, pl. 9.

Asterias neglecta Bell, 1881, p. 94, pl. 9.

[*Asterias alba* Bell, 1881, pp. 92, 506.]

[*Asterias obtusispinosa* Bell, 1881, pp. 92, 93.]

Asterias belli Studer, *Abh. Akad. Berlin*, 1884, pp. 12, 13, pl. 1.

Asterias glomerata Sladen, 1889, p. 571, pl. 105, figs. 1-4.

Diplasterias loveni Perrier, 1891, p. 80.

Diplasterias lütkeni Perrier, 1891, p. 81.—Ludwig, 1903, p. 41.

¹ *Expéd. Travailleur et Tatisman*, pp. 107, 108 (key).

² *Résultats camp. sci. Prince de Monaco*, fasc. 11, 1896, pp. 34, 35.

³ *Expédition Antaretique Belge, Seesterne*, p. 41.

⁴ *Hamburger Magalhaensische Sammelreise, Asteroideen*, pp. 5-9.

⁵ *Shallow-water Starfishes*, p. 361.

Diplasterias brandti Meissner, 1904, p. 7.—Koehler, 1908, p. 572, pl. 5, figs. 50, 51; 1912, p. 19, pl. 1, figs. 3, 5, 6.—Fisher, 1930, p. 230.

Podasterias brandti Koehler, 1917, p. 26, pl. 4, figs. 16, 17; pl. 5, figs. 11, 13, 14; 1920, pp. 41, 51, pl. 13, fig. 11; pl. 16, figs. 5, 6; 1923, p. 27, pl. 2, figs. 2, 3.—Grieg, 1929, p. 7.

Podasterias brandti var. *glomerata* Koehler, 1923, p. 29, pl. 2, fig. 4.

St. 51. Off Eddystone Rock, East Falkland Island, 105–115 m., fine sand, 1 young.

St. 55. Entrance to Port Stanley, East Falkland Island, 10–16 m., 2 specimens.

St. 1873. Off Clarence Island, 61° 20' 8" S, 54° 04' 2" W, 200–137 m., 2 specimens.

St. WS 73. Falkland Islands, 51° 01' S, 58° 54' W, 121 m., fine dark sand, 1 young.

St. WS 80. Falkland Islands, 50° 57' S, 63° 37' 30" W, 152–156 m., fine dark sand, 1 specimen.

St. WS 81. 8 miles north 11° W of North Island, West Falkland Island, 81–82 m., sand, 15 specimens.

St. WS 84. 7½ miles south, 9° W of Sea Lion Island, East Falkland Island, 75–74 m., coarse sand, shells, stones, 5 specimens, 1 carrying young (24 March 1927).

St. WS 85. Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shells, 2 specimens.

St. WS 91. Tierra del Fuego, 52° 53' 45" S, 64° 37' 30" W, 191–205 m., fine dark sand and shell, 14 specimens.

St. WS 92. 51° 58' 30" S, 65° 01' W, 145–143 m., 2 specimens.

St. WS 98. Falkland Islands, 49° 54' 15" S, 60° 35' 30" W, 171–173 m., 9 specimens.

St. WS 99. Falkland Islands, 49° 42' S, 59° 14' 30" W, 251–225 m., fine dark sand, 6 specimens.

St. WS 109. Falkland Islands, 50° 18' 48" S, 58° 28' 30" W, 145 m., fine dark sand, 1 specimen.

St. WS 210. Falkland Islands, 50° 17' S, 60° 06' W, 161 m., green sand, 2 specimens.

St. WS 211. Same as 210, 174 m., 4 specimens.

St. WS 230. Falkland Islands, 50° 10' S, 58° 42' W, 210–271 m., 1 specimen.

St. WS 233. Falkland Islands, 49° 25' S, 59° 45' W, 185–175 m., fine green sand, 5 specimens.

St. WS 243. North-east of Falkland Islands, 51° 06' S, 64° 30' W, 144–141 m., coarse dark sand, 1 specimen.

St. WS 755. Falkland Islands, 51° 39' S, 57° 39' W, 75 m., 2 specimens.

St. WS 782A. North Falkland Island, 50° 29¼' S, 58° 23¾' W, 141 m., 1 specimen.

St. WS 815. Between Falkland Islands and Strait of Magellan entrance, 51° 51¾' S, 65° 44' W, 132–162 m., 1 specimen.

St. WS 816. Same, 52° 09¾' S, 64° 56' W, 150–160 m., 2 specimens.

St. WS 817. Same, 52° 23' S, 64° 19' W, 191–202 m., 3 specimens.

St. WS 823. Falkland Islands, 52° 14½' S, 60° 01' W, 80–95 m., 1 specimen.

St. WS 825. Falkland Islands, 50° 50' S, 57° 15¼' W, 135–144 m., 2 specimens.

St. WS 836. South-east of eastern entrance to Strait of Magellan, 53° 05½' S, 67° 38' W, 64 m., 1 specimen.

St. WS 867. 51° 10' S, 64° 15' 30" W, 150–147 m., 1 specimen.

St. WS 869. 52° 15' 30" S, 64° 13' 45" W, 187 m., 1 specimen.

It has been customary to include in the synonymy of this species *Asterias alba* Bell and *A. obtusispinosa* Bell (1891, pp. 92, 93). Many years ago I examined at the British Museum (Natural History) the type specimens. My notes state that the superomarginals are high on the side of the ray; that there are two series of actinal spines; that the gonads appear to open dorsally in *obtusispinosa*. I have not observed more than one series of actinal spines in *brandti*. Possibly *alba* and *obtusispinosa* belong in *Cosmasterias*.

This species is very variable and in the southern part of the range there is a chance of confusing young specimens with those of *D. brucei*. The most obvious variation in Falkland specimens is in the number of crossed pedicellariae and the thickness of the

sheath of tissue surrounding the spines. *Asterias neglecta* Bell and *A. glomerata* Sladen are representatives of a form with heavy circumspinal sheaths and well-developed crossed pedicellariae. Koehler has already recognized this as variety *glomerata* (1923, p. 29) but *neglecta* Bell has priority.

In another form the tissue of the sheath is well developed but there are few pedicellariae, as in *brucei*. However, the latter has distinctly smaller crossed pedicellariae and fewer dorsolateral spines. In both formae there are "broader and slenderer" rayed specimens.

Two inferomarginal spines with chisel-shaped end and terete base occur with greatest frequency but this number varies sporadically to 1, less often to 3. Certain examples, especially in the southern part of the species-range have a single spine more often than 2. A specimen with R 76 mm. from St. 84 has the disk arched and the bases of rays approximated to form a nidal cavity in which are 161 young, 5-7 mm. in diameter. All have 5 rays.

DISTRIBUTION. Falkland Islands; Magellan region, north to latitude $44^{\circ} 14' S$ and longitude $53^{\circ} 43' W$; South Georgia; South Shetland Islands; Antarctic Archipelago south to Alexander I Island, $68^{\circ} 35' S$, $72^{\circ} 40' W$; Bellingshausen Sea, $70^{\circ} 23' S$.

Diplasterias meridionalis (Perrier)

(Fig. M, 2-2b; Plate XXI, fig. 4; Plate XXII, fig. 1)

Asterias meridionalis Perrier, 1875, p. 76.—Smith, 1879, p. 272, pl. 16, fig. 1.

Asterias mollis Studer, *Abh. Akad. Wiss. Berlin*, 1884, p. 8.

Asterias studeri Bell, 1881, p. 91.—Studer, *Abh. Akad. Wiss. Berlin*, 1884, p. 8, pl. 1, fig. 1.

Podasterias meridionalis Koehler, 1917, p. 20, pl. 2, figs. 11, 12; pl. 3, figs. 1, 2, 4, 5, 6, 7; pl. 6, fig. 8; pl. 7, fig. 9; 1923, p. 31, pl. 2, fig. 1 (not pl. 13, fig. 1).—Döderlein, 1928, p. 294.

Diplasterias meridionalis Perrier, 1891, p. 7.—Meissner, 1904, p. 8.—Koehler, 1912, pp. 211, 213, 220, 223, 252.—Fisher, 1930, p. 231.

St. 42. Off mouth of Cumberland Bay, South Georgia, 120-204 m., 2 young specimens.

St. 140. Stromness Harbour to Larsen Point, South Georgia, 122-136 m., green mud and stones, 4 specimens (2 with 7 rays).

St. 141. East Cumberland Bay, South Georgia, 17-27 m., 1 specimen.

St. 149. Mouth of East Cumberland Bay, South Georgia, 200-234 m., mud, 2 young specimens.

St. 160. Near Shag Rocks, $53^{\circ} 43' 40'' S$, $43^{\circ} 57' W$, 177 m., grey mud, stones, 2 young specimens.

St. 1562. Off Marion Island, $46^{\circ} 52' S$, $37^{\circ} 55' E$, 97-104 m., 3 young specimens.

St. 1563. Off Marion Island, $46^{\circ} 48.4' S$, $37^{\circ} 49.2' E$, 101-106 m., 6 specimens.

St. WS 25. Undine Harbour (North), South Georgia, 18-27 m., mud and sand, 2 young specimens.

St. WS 27. West Cumberland Bay, South Georgia, 106-109 m., gravel, 1 young specimen.

St. MS 6. East Cumberland Bay, South Georgia, 27 m., 2 specimens.

St. MS 10. Same, 26 m., 3 specimens.

St. MS 67. Same, 38 m., 2 young specimens.

St. MS 71. Same, 110-60 m., 2 specimens.

St. MS 74. Same, 22-40 m., 1 young specimen.

Cumberland Bay, South Georgia, 1 young specimen.

Government Jetty, Grytviken, South Georgia, 1 specimen.

Koehler has materially added to the knowledge of this species, and a rather full account is given in his Kerguelen paper. In his report on the results of the Swedish Antarctic Expedition he includes a 6-rayed form from Antarctic Bay, South Georgia (1923, p. 33, pl. 13, fig. 1) which, apart from the number of rays, more closely resembles *D. brucei* than *meridionalis*. Similar specimens have been listed in this report under *brucei*. In typical *meridionalis* there are numerous stubby irregularly scattered dorso-lateral spines subequal to the carinals which are not aligned in a sharply differentiated fairly regular longiseries. In the problematical specimens the carinal spines are heavily stoled, are in as regular a series as in *brucei* and are occasionally even more sharply differentiated from the smaller dorsolateral spines. In my specimens the differentiation is more marked than in Koehler's figure; and the cushion of tissue around the spines is in one case (St. MS 71) distinctly larger than in *brucei*, where it is variable in size—not rather constant as Koehler thought. In *brucei* there is a series of actinal spines. In *meridionalis* there are no actinal spines, and the plates are small, wedged between the well-developed inferomarginals and adambulacrals, and invisible in alcoholic specimens. But young specimens of *brucei* do not have any actinal spines, and if small enough, no actinal plates either. As the pedicellariae are very similar in the two species there will always be great uncertainty in determining young 6-rayed specimens. Since *meridionalis* also has a few 5-rayed young it is obvious that these will be confused with young *brucei* until adult characters are developed.

A typical specimen from St. MS 10 (14 February 1925) with R 110 mm. has 50 young in the nidamental cavity; 46 have 6 rays and 4 have 5 rays. From St. 140 are 2 small 7-rayed specimens, placed in this species rather than *octoradiata* on account of preponderance of diplacanthid adambulacrals.

A specimen from St. MS 6, having R 105 mm., is occupied by 3 large parasitic ascothoracid cirripedes, *Dendrogaster*, lying in the coelom. The central portion of each of the 4-branched bodies lies between the dorsal and ventral stomachs, while the space between the hepatic diverticula and the ventral wall is completely filled (for half or three-quarters length of ray) by the many lobed branches. Branches of the upper parasite extend into rays 1, 2, 4, 5; while the middle occupies rays 1, 4, 5, 6; and the lowermost, rays 3 (2 branches) 5, 6. Ray 6 therefore is crowded with a branch of each parasite. In spite of all this competition for space the hepatic diverticula appear to be normal and all 10 gonads functional. It is difficult to understand how the stomach could have functioned adequately. The body wall is flaccid and the elements of the skeleton are weak—precisely the condition which I found in an almost equal-sized *Leplasterias polaris acervata*, from Bering Sea, parasitized by several large *Dendrogasters*; and in a specimen of *Hippasteria californica* (Fisher, 1911, p. 237, pl. 111, fig. 1) containing one large *D. arbuscula*.

DISTRIBUTION. South Georgia; Marion Island; Kerguelen (type locality); low tide to 234 m.

Diplasterias brucei (Koehler)

Stolasterias brucei Koehler, 1908, p. 569, pl. 5, figs. 46, 47.

Coscinasterias brucei Koehler, 1911, p. 30, pl. 5, fig. 5.

Coscinasterias victoriae Koehler, 1911, p. 32, pl. 5, figs. 3, 4; 1912, p. 24.

Podasterias brucei, 1920, p. 42, pl. 11, figs. 5-7; pl. 13, figs. 1-9; pl. 14, figs. 4, 7-11; pl. 15, figs. 4, 5; 1923, p. 35, pl. 13, figs. 1, 2.—Döderlein, 1928, p. 295.—Grieg, 1929, p. 5.

Diplasterias brucei Fisher, 1930, p. 231.

McMurdo Strait, Victoria Land (W.Q. hole 12), 2 young specimens.

St. 181. Schollaert Channel, Palmer Archipelago, 64° 20' S, 63° 01' W, 160-335 m., mud, 2 specimens.

St. 123. Off mouth of Cumberland Bay, South Georgia, 230-250 m., grey mud, 2 specimens (6 rays).

St. 148. Off Cape Saunders, South Georgia, 132-148 m., grey mud, stones, 3 specimens (6 rays).

St. 170. Off Cape Bowles, Clarence Island, 342 m., rock, 1 young specimen (5 rays).

St. 181. Schollaert Channel, Palmer Archipelago, 64° 20' S, 63° 01' W, 160-335 m., mud, 2 specimens.

St. 366. South of Cook Island, South Sandwich Islands, 77-152 m., 3 specimens (5 rays).

St. 371. 1 mile east of Montagu Island, South Sandwich Islands, 99-161 m., 1 specimen 5-rayed carrying young.

St. 1941. Leith Harbour, South Georgia, 53-22 m., 3 young (6 rays).

St. MS 71. East Cumberland Bay, South Georgia, 110-60 m., 1 specimen (6 rays).

All the specimens from South Georgia have 6 rays and are therefore not typical *brucei*. Koehler regards this 6-rayed form as a variant of *meridionalis* and has published a figure and notes on a specimen from 250 m., Antarctic Bay, South Georgia (1923, p. 33, pl. 13, fig. 1). It is only necessary to compare this figure with one of *brucei* on the same plate (fig. 2) to see that it resembles *brucei* much more closely than it does typical *meridionalis* (Koehler, 1917, 1923). In fact two medium-sized specimens (R 78 and 93 mm.) outdo typical *brucei*, of about the same size, in the reduction or suppression of the dorsolateral spinelets, and the accentuation of the carinal and superomarginal spines along with the circumspinal cushions of tissue. These cushions are not necessarily larger in (5-rayed) *brucei*, as Koehler believed, but may be actually smaller than in the 6-rayed form (e.g. 1 from St. M 71 as compared to typical *brucei*, Sts. 366, 371). The only difference mentioned by Koehler which seems to hold is the more constant development of actinal spines in *brucei*, these extending farther along ray than in the 6-armed form. There are two very large specimens from St. 148 having 6 rays and the general habit of *brucei*. One measures R 160 mm., r 28 mm.; the other, R 245 mm., r 38 mm. In these, well-developed actinal spines extend $\frac{1}{2}$ R along ray while in a specimen of *brucei* from St. 366 (R about 90 mm.) they extend rather more than $\frac{2}{3}$ R. (In an equal-sized 6-rayed specimen they extend about $\frac{1}{2}$ R but the spines are smaller.) But *D. meridionalis* differs from these in lacking actinal spines altogether and in having reduced hidden, actinal plates.

No typical 5-rayed *brucei* has yet been taken near South Georgia. As the matter now stands these 6-rayed specimens look exactly like typical *brucei* except for the number of rays and a poorer development of actinal spines. To add somewhat to the confusion a

typical specimen of *meridionalis* (St. MS 10) has 4 out of 50 young with only 5 rays. Possibly in deeper water near South Georgia there may be typical *brucei*, of which these 6-rayed specimens constitute a shallower water form.

A specimen of typical *brucei* (St. 371) is carrying 65 young about 6 mm. in diameter and all are 5-rayed.

DISTRIBUTION. South Georgia (6-rayed form); South Sandwich group, South Orkneys, South Shetlands; Graham Coast; Antarctic Coast from 92° E to 166° 12' E and 77° 32' S (McMurdo Sound, South Victoria Land); probably circumpolar; 0-581 m.

Diplasterias octoradiata (Studer)

(Fig. M, 1-1c; Plate XXI, figs. 1-3; Plate XXII, fig. 2)

Pedicellaster octoradiatus Studer, 1885, p. 147, pl. 1, figs. 1a-d.

Anasterias octoradiata Koehler, *Brooklyn Institute Museum, Sci. Bull.*, 11, no. 4, 1914, p. 64, pl. 14, figs. 1-7; 1923, p. 14, pl. 6, fig. 6.—Fisher, 1922, p. 595.—Grieg, 1929a, p. 7.

Koehleraster octoradiatus Fisher, 1930, p. 234.

St. 145. Stromness Harbour, South Georgia, 26-35 m., 1 specimen, typical, 8 rays.

St. 1941. Leith Harbour, South Georgia, 55-22 m., 1 specimen, f. *eunota*, 8 rays.

St. WS 25. Undine Harbour (North), South Georgia, 18-27 m., mud, sand, 1 specimen, f. *eunota*, 9 rays.

St. WS 62. Wilson Harbour, South Georgia, 15-45 m., 1 specimen, typical, 8 rays.

St. MS 6. East Cumberland Bay, South Georgia, 27 m., typical, 3 specimens, 8 rays; one, 9 rays.

St. MS 10. Same, 26 m., 10 specimens, typical, 3 (7r), 5 (8r), 1 (9r).

St. MS 67. Same, 38 m., 1 specimen, juv., 8 rays.

St. MS 74. Same, 22-40 m., 1 specimen, subtypical, 7 rays.

Undine Harbour, South Georgia, 20 m., 2 specimens, f. *eunota*, 9 rays.

Cumberland Bay, South Georgia, 1 specimen, typical, 8 rays.

Heretofore only 3 specimens have been known: two recorded by Koehler (1914, 1923) and one by Grieg (1929), all from South Georgia. The number of rays in these was 8 and 9.

The present collection affords an altered picture of the species. The number of rays varies from 7 to 9 among adult specimens and young large enough to fend for themselves. But a tally of young carried by the mother indicates the astonishing range of from 5 to 10 rays with the greatest frequency 8, then 7, 9, 6, 10, 5.

The typical form as described by Koehler has the thickest skin and most swollen welts around the spines, and the latter do not protrude much if at all beyond the broad collar. It is this swelling of the spine collars which hides the large madreporite that escaped both Koehler and Grieg. The madreporite is subcircular, flat, 5 mm. in diameter, and its inner border is at mid-r. The typical form has the weakest abactinal skeleton, and (in large specimens) the best development of hidden *actinal* plates, the series of which extends far along ray. There is in mature specimens an actinal series of conspicuous papulae, extending nearly three-fourths length of ray measured on side. The skeletal intervals for these papulae alternate with the actinal plates. In this actinal

channel are a few simple lanceolate pedicellariae, which are found also in the inter-marginal channel and abactinally.

From Undine Harbour (including St. 25) and Leith Harbour (St. 1941) are 4 specimens sufficiently different to constitute a well-marked variety, forma *eunota*, which is characterized by conspicuously protruding abactinal spines, with narrower collars, an exposed madreporite, a stronger abactinal skeleton, a much shorter series of hidden actinal plates, and actinal papulae which are largely suppressed on rays (Undine Harbour), or are small and form only a short series (St. 1941). There is a variable number of straight pedicellariae, as in typical form (see Pl. XXI, figs. 1, 2). The type, Undine Harbour, has 9 rays; R 100 mm., r 29 mm., br 20 mm.; madreporite circular, 4.5 mm. in diameter, the inner border 16 mm. from centre of disk, hence rather more than half of r from centre.

The largest specimen of the typical form (St. MS 6) has 9 rays; R 130 mm., r 36 mm., br 22 mm. The disk is arched and rays approximated to form a brood chamber around the mouth. In this were 707 young, ranging in diameter from 3.75 to 5 mm.; date, 12 January 1924. Random sampling gives the following counts for the number of rays: 74 have 8 rays; 36 have 7 rays; 16 have 9 rays; 5 have 6 rays; 2 have 10 rays; 1 has 5 rays—surely an astonishing variation. An adult 6-rayed *octoradiata* will give the future systematist something to puzzle over. Except for its mostly monacanthid adambulacrals it could hardly be distinguished from *Diplasterias meridionalis*.

A large 8-rayed specimen from St. 145 (7 January 1927) has the brood chamber filled with young in the same stage of development as those from St. MS 6. These young have been left undisturbed but a considerable number had already shaken loose. Sixty-seven have 8 rays, 34 have 7 rays, 8 have 9 rays, 2 have 6 rays. There is a "Siamese twin" with 2 mouths and 13 rays. Two undeveloped eggs are 3.5 mm. in diameter.

The young from St. MS 6 have 12–14 pairs of tube-feet. There is as yet no mouth, but on the arched abactinal surface of the largest a few tiny papillae have appeared. Many are greatly distorted by mutual pressure due to crowding, and in some cases 1 or 2 rays are larger than the others. The young have long "umbilical" cords proceeding from an interradius by which they are united in clusters to a common small, fleshy, lobed mass, such as I figured for *Leptasterias arctica* (1930, pl. 10, fig. 4). The cord is 0.034–0.17 mm. in diameter and varies in length from two to five times diameter of young. Sometimes a cluster is anchored to a tube-foot by a loop of a cord which has cut into the skin.

A series of specimens from St. MS 10 includes the following graded sizes: R 6 mm. (7 rays); R 7 mm. (8 rays); R 7.5 mm. (9 rays); R 10 mm. (7 rays); R 14 mm. (8 rays); R 15 mm. (8 rays); R 21 mm. (8 rays); R 26 mm. (7 rays); R 30 mm. (8 rays, St. MS 6); R 46 mm. (8 rays). In the smallest specimen the tube-feet are biserial but the second has indications of a quadriserial arrangement. The fourth, with R 10 mm. and 7 rays, would pass for a young *D. meridionalis* but a majority of the adambulacrals are monacanthid, with a scattering of diplacanthid plates. In this the occurrence of diplacanthid plates is about as frequent as in the third specimen with 9 rays which could not be

meridionalis. In 2 series chosen at random the spines counts run as follows from base to tip of ray:¹ 5m, 1d, 1m, 1d, 4m, 1d, 2m, 1d, 1m, 3d, 1m, 1d, 1m, 1d, 1m, 1d, 2m: total 28 plates. Another runs: 7m, 1d, 1m, 1d, 2m, 2d, 4m, 2d, 1m, 2d, 3m: total 26 plates.

In these small specimens the skeleton is arranged as follows: a circle of plates (its radius equal to $\frac{1}{2}r$) on disk bearing 1 or 2 spinelets each, enclosing numerous isolated monacanthid plates; a carinal and 2 superomarginal series of monacanthid plates with a zone of bare skin between, the superomarginals defining the abactinal area; a series of monacanthid inferomarginals and mixed monacanthid and diplacanthid adambulacrals; a few crossed pedicellariae attached to all plates except adambulacrals; a broadly lanceolate straight pedicellaria on each mouth-plate, which carries 1 apical and 1 suboral spine.

Studer's type of *Pedicellaster octoradiatus* from South Georgia in which R is 6 mm. is described as having an irregular calcareous net on the central part of disk, forming on the rays three distinct bands, tube-feet biserial. This would apply to the three smallest specimens listed above.

Koehler did not describe the skeleton, but placed the species in *Lysasterias* (*Anasterias* to him) by reason of the development of the circumspinal collars or pustules. After the type reached the U.S. National Museum I made a dissection and described the skeleton as follows (1922, p. 595): "It has a complete irregularly reticulate abactinal skeleton, consisting of very numerous small, but fairly robust, oval, elliptical oblong, and a few irregularly 3-lobed plates (which latter perhaps represent the primary dorsolaterals). There is an irregular carinal series, of which the plates are no larger than the others. The abactinal plates are joined to the superomarginals by transverse bands of plates which are a little more regular than the others, and between consecutive trabeculae are broad (but short) papular areas which form a zone just above the superomarginal plates. These papular areas, or skeletal meshes, are larger than the other abactinal and the intermarginal meshes. The marginal plates are fairly robust and of the form usually found in the Asteroiinae—namely, 4-lobed. The descending lobe of the superomarginal is the longest and strongly overlaps the ascending one of the inferomarginal. The superomarginals are regularly monacanthid, while most of the inferomarginals are diplacanthid. There is a very inconspicuous series of small spineless actinal plates."

This skeleton is like that of *Diplasterias meridionalis*, even to the obscured actinal plates. I prepared the skeleton of one ray of *meridionalis* from St. MS 10, for comparison with that of *octoradiata* from the same haul. These are more closely similar than is the skeleton of the two formae of *octoradiata*! In *meridionalis* and the typical form of *octoradiata* the actinals extend far along the ray whereas in forma *emota* they stop at about the middle of ray. Pl. XXI, figs. 2-4.

A comparison of alcoholic specimens reveals a striking similarity between the two species except for the number of rays and number of adambulacral spines. *Meridionalis* has the same broad "pustulate" collars around the spines, not less swollen or fleshy than in *octoradiata*.

¹ This means 5 monacanthid plates, 1 diplacanthid, 1 monacanthid, etc.

If the adambulacral armature is disregarded, a South Georgian specimen of *D. meridionalis* would serve to illustrate a 6-rayed *octoradiata*; or a 7-rayed *octoradiata* would pass for *meridionalis* (of which there are 2 small 7-rayed specimens from St. 140). *Octoradiata* has regularly a variable number of sporadic diplacanthid adambulacrals, as noted in connection with young examples.

The crossed pedicellariae are closely similar in size and form, ranging from 0.34 to 0.39 mm. in length abactinally, and 0.45–0.55 mm. on inferomarginals. In profile the terminal lip in *meridionalis* descends slightly further than in *octoradiata*. The lanceolate straight pedicellariae are usually a little heavier in *meridionalis*.

Diplasterias radiata (Koehler)

(Fig. M, 3–3*b*)

Cosmasterias radiata Koehler, 1923, p. 36, pl. 2, fig. 5; pl. 3, figs. 1, 2.

St. 160. Near Shag Rocks, 53° 43' 40" S, 43° 57' W, 177 m., grey mud, stones and rock, 3 specimens.

Like Koehler's specimens, these are unfortunately young; two have 8 rays and one has 9. R is 16 mm., 13 mm., 7 mm. A few of the proximal adambulacrals are monacanthid and rest diplacanthid.

The crossed pedicellariae are of the rather noncommittal *Diplasterias* form, 0.27–0.33 mm. long and the terminal lip is more like that of *D. meridionalis* than of *octoradiata*—namely, more extensive in profile. Although these specimens are very small, the largest pedicellariae are about the same size as the smallest pedicellariae of a full grown *octoradiata* (0.34–0.55 mm.). In the actinal interradiar area of one specimen are 1 or 2 lanceolate straight pedicellariae about 0.85 mm. long, while those on the adambulacral margin are about 0.35 mm. long. In the largest specimen the axillary pedicellariae are no larger than the adambulacral while in the smallest they are absent.

It is unprofitable to hold too strong opinions concerning the generic position of this young form. From its resemblance to *octoradiata* I believe it is better to place it in *Diplasterias* than *Cosmasterias*.

TYPE LOCALITY. Shag Rocks, 160 m.

Genus *Cryptasterias* Verrill

Diplasterias Koehler, part, 1906, p. 19; 1908, p. 574.

Cryptasterias Verrill, 1914, p. 362. Type *Diplasterias turqueti* Koehler.—Koehler, 1920, p. 57; 1923, p. 25.—Fisher, 1923, p. 604; 1930, p. 228.

Cryptasterias turqueti (Koehler)

Diplasterias turqueti Koehler, 1906, p. 19, pl. 2, fig. 17; pl. 4, fig. 39; 1908, p. 574.

Cryptasterias turqueti Verrill, 1914, p. 362.—Koehler, 1920, p. 57, pl. 17, figs. 1–5.—Fisher, 1920, p. 228.

St. 165. Dove Strait, south-east of Queen's Bay, Signy Island, South Orkneys, 10 m., 1 specimen.

The specimen is much smaller than Koehler's type; R 32 mm., r 7.5 mm. Koehler remarks that this species superficially resembles *Lysasterias perrieri*. *Cryptasterias* bears to *Diplasterias* much the same relation that *Lysasterias* does to *Anasterias*.

Diplasterias induta Koehler (1908, p. 575, pl. 7, figs. 68-70) from Scotia Bay, South Orkneys is obviously immature and is probably young *turqueti*.

TYPE LOCALITY. Booth Wandel Island.

DISTRIBUTION. Booth Wandel Island and South Orkneys, 0-36 m.

Genus *Neosmilaster* Fisher

Neosmilaster Fisher, 1930, p. 237. Type *Asterias georgiana* Studer.

DIAGNOSIS. Resembling *Diplasterias* in having diplacanthid adambulacral plates and gonads which open ventrally, but differing in having abactinal pedicellariae scattered among small spinelets rather than in circlets on circumspinal sheaths; in having the inferomarginal spines in oblique, transverse combs of from 2 to 5, as in *Smilasterias*. Actinal plates spiniferous, varying from one-third to one and one-half series; straight pedicellariae conspicuous, not toothed; abactinal skeleton an irregular, close, or medium open net, the small spinelets, with interspersed papulae, either close-set or spaced according to relative compactness of skeleton; superomarginal spinelets similar to and only slightly larger than abactinal; prominent actinal papulae.

REMARKS. This genus was instituted for 2 species which at least superficially resemble one another more than they do typical *Diplasterias*, to which they have been assigned by Perrier and Koehler. It differs from *Smilasterias* in having well-developed actinal papulae and gonads which open ventrally (paedophoric).

Neosmilaster georgianus (Studer)

Asterias georgiana Studer, 1885, p. 150, pl. 1, fig. 3 a-d.

Diplasterias georgiana Perrier, 1891, p. 7.

Podasterias georgiana Koehler, 1917, p. 26; 1920, p. 41.

Ctenasterias georgiana Koehler, 1923, p. 40, pl. 3, figs. 3-7, 10.

Neosmilaster georgianus Fisher, 1930, p. 237.

St. 142. East Cumberland Bay, South Georgia, 88-273 m., 1 specimen.

St. 145. Stromness Harbour, South Georgia, 26-45 m., 10 specimens.

St. 159. South Georgia, 53° 52' 30" S, 36° 08' W, 160 m., rock, 1 specimen.

St. 179. Melchior Island, Schollaert Channel, Palmer Archipelago, 64° 20' S, 63° 01' W, 160-335 m., mud, 1 specimen.

St. WS 25. Undine Harbour (N.), South Georgia, 18-27 m., mud and sand, 6 specimens.

St. WS 56. Drygalski Fjord, South Georgia, 2 m., kelp roots, 2 specimens.

St. WS 65. Undine Harbour, South Georgia, kelp roots, 1 specimen.

St. MS 6. East Cumberland Bay, South Georgia, 27 m., 2 specimens.

St. MS 10. Same, 26 m., 15 specimens.

St. MS 12. Same, 25-53 m., 1 specimen.

St. MS 63. Same, 23 m., 5 specimens.

St. MS 64. Same, 15-7 m., 1 specimen.

St. MS 67. Same, 38 m., 3 specimens.

St. MS 71. Same, 110-60 m., 4 specimens.

Cumberland Bay, South Georgia, 6 specimens.

Borge Bay, South Orkneys, fish trap, 1 specimen.

Koehler (1923) has described and figured this species. His fig. 5 (pl. 3) of a dried specimen shows the reticulate skeleton and the larger meshes just above the superomarginal plates. At base of ray there are equally large intermarginal intervals. Both may be wider than in Koehler's figure. The rest of the abactinal reticulum is smaller, irregular, and the skeletal bars are slender—2 or 3 slender secondary plates uniting the mostly 3-lobed primaries. There is no differentiated carinal series. The mostly diplacanthid inferomarginal plates are adjacent to adambulacrals except at base of ray where a short series of inconspicuous actinals is interpolated. These sometimes carry a single spine in line with the 2 inferomarginals (South Georgia), but may be mostly spineless (South Orkneys). In the South Georgia specimens the superomarginal spinelets (usually 1 to a plate) are subequal to the abactinal and conspicuously smaller than the inferomarginals. In the example from South Orkneys (R 50 mm.) they are larger—intermediate between the abactinals and the spatulate truncate inferomarginal spines, of which the proximal plates carry 2 and the distals usually 1. The integument of this specimen is distinctly thicker and more verrucose than in South Georgia examples. In the latter the spinelets are all distinct as shown in Koehler's fig. 3, while in the South Orkney form the intricate folds of skin are flush with ends of spinelets and occupy all the space between. They completely hide numerous crossed pedicellariae. The specimen resembles an *Anasterias* or a *Lysasterias*.

Typical specimens have sporadically triplacanthid adambulacrals.

DISTRIBUTION. Shag Rocks; South Georgia, low tide to about 160 m.; South Orkneys, shallow water; Palmer Archipelago, 160-335 m.

Neosmilaster steineni (Studer)

Asterias steineni (Studer), 1885, p. 152, pl. 1, figs. 4a, b.

Diplasterias steineni Perrier, 1891, p. 84.—Koehler, 1912, p. 20, pl. 1, figs. 4, 7, 10.

Podasterias steineni Koehler, 1917, p. 26; 1920, p. 41; 1923, p. 30, pl. 3, figs. 8, 9.

Neosmilaster steineni Fisher, 1920, p. 237.

St. 159. South Georgia, 53° 52' 30" S, 36° 08' W, 160 m., rock, 1 specimen.

St. WS 824. Falkland Islands, 52° 29¼' S, 58° 27¼' W, 146-137 m., 9 specimens.

St. WS 825. Falkland Islands, 50° 50' S, 57° 15¼' W, 135-144 m., 1 specimen.

The largest specimen (St. WS 824) has R 92 mm., r 22 mm., br 21 mm. Koehler's figures (1912, pl. 1, figs. 4, 7, 10) show the general habit. The species can be readily distinguished from *georgiana* by the closer knit skeleton and the extensive series of actinal plates. These extend far along ray and each carries, oriented in a longiseries, 2 terete spines, as long as, and a little stouter than, the adambulacrals. The largest specimen has a short second series at base of ray, each plate with 1 spine. Outside of the actinal spines, the inferomarginals carry an oblique transverse series of 3 or 4 similar terete

spines, or heavier terminally flattened ones. The superomarginals are intermediate in size between the inferomarginals and the small cylindrical or slightly clavate abactinal spinelets, but are not much larger than the latter. The proximal superomarginal plates carry 2 or 3 spinelets, the distals 1 spinelet.

On the marginal and actinal plates are numerous large conical straight pedicellariae, the largest half as long as the inferomarginal spines. The base is broad, the jaws triangular with a bluntly pointed tip. On the largest specimens they occur also on the lateral parts of the abactinal area. Very numerous crossed pedicellariae are scattered among the abactinal and superomarginal spines, attached to the plates but not to the spine sheaths. They appear to be absent from the actinal and proximal inferomarginal plates. A few are present on the dorsal part of the distal inferomarginal plates, but are not on pads or spine sheaths.

This species differs from *georgianus* in the extensive development of the actinal series of plates, a second series being present proximally; in the absence of crossed pedicellariae from the proximal inferomarginal plates; in having more numerous inferomarginal spines, a less open skeleton, and larger straight pedicellariae.

On account of the oblique series of 3 or 4 inferomarginal spines in addition to at least 2 actinals, large specimens resemble *Smilasterias*, which, however, has gonads opening dorsally, and well-developed actinal papulae.

DISTRIBUTION. Tierra del Fuego; Falkland Islands; south of Cape Horn; South Georgia; 99–160 m.

Genus *Smilasterias* Sladen

Smilasterias Sladen (subgenus), 1889, pp. 562, 578. Type *Asterias scalprifera* Sladen.

DIAGNOSIS. Small, 5-rayed forms with compact, reticulate abactinal and lateral skeleton beset with small spinelets; inferomarginals on ventrolateral border of ray, each with a prominent, oblique comb of 2–6 flattened truncate spines which radiate apart and are without attached pedicellariae; adambulacral plates with 2–4 slender, often flattened, spinelets, devoid of attached pedicellariae; a series of small actinal plates,¹ spiniferous in genotype; abactinal and intermarginal but no actinal papulae; adoral carina comprises first pair of postoral adambulacrals which are longer than second pair; crossed pedicellariae scattered, not in circlelets around spinelets; straight pedicellariae lanceolate, scattered on all surfaces; in addition, sometimes, large spatulate unguiculate pedicellariae with curved interlocking tines; tube-feet in 4 series; one madreporite; gonads open dorsally at upper margin of superomarginal plates, near interradius.

REMARKS. The presence of *S. scalprifera* off Marion Island and in the Falkland region seems to indicate that it is a subantarctic species. The records of *triremis* from Heard and the Palmer Archipelago point to an Antarctic distribution. Sladen, however, records *scalprifera* from 75 fathoms off Heard Island, which, to be sure, is shallower water than the record of *triremis* (150 fathoms).

¹ Stated to be lacking in *S. irregularis* Clark, *Records South Australian Museum*, III, No. 4, 1928, p. 102.

Smilasterias scalprifera Sladen

Asterias (Smilasterias) scalprifera Sladen, 1889, p. 578, pl. 100, figs. 4-6; pl. 103, figs. 1-2.

Smilasterias scalprifera Fisher, 1930, p. 239.

St. 1562. Off Marion Island, 46° 52' S, 37° 55' E, 97-104 m., 4 specimens.

St. 1563. Off Marion Island, 46° 48.4' S, 37° 49.2' E, 101-106 m., 1 specimen.

St. 1564. Off Marion Island, 108-113 m., 1 specimen.

St. WS 85. (Specimen adrift in sorting; near this station.) Falkland Islands, 52° 09' S, 58° 14' W, 79 m., sand and shell, 1 specimen.

St. WS 93. West Falkland Island, 51° 51' S, 64° 45' W, 108-109 m., fine dark sand and stones, 1 specimen.

St. WS 99. Falkland Islands, 49° 42' S, 59° 14' 30" W, 251-225 m., fine dark sand.

St. WS 214. North of Falkland Islands, 48° 25' S, 60° 40' W, 208 m., 1 specimen.

St. WS 246. Falkland Islands, 52° 25' S, 61° W, 267-208 m., coarse green sand, pebbles, 1 specimen.

St. WS 824. Falkland Islands, 52° 29½' S, 58° 27¼' W, 146-137 m., 4 specimens.

St. WS 825. Falkland Islands, 50° 50' S, 57° 15¼' W, 135-144 m., 7 specimens.

This species has heretofore been known only from off Marion and Heard Islands. Its capture in the Falkland region, already fairly well explored by the dredge, indicates the part which chance plays in deep water collecting.

The largest specimen, from St. 1564, measures R 51 mm., r 8-10 mm., br 10 mm. A characteristic of the species is the presence of a series of small actinal plates, extending ordinarily to about the middle of ray, and corresponding to the inferomarginals. Each carries a chisel-shaped spine which is the innermost of the characteristic ventrolateral oblique series. In the specimen from 1564 there are 6 or 7 spines in these combs except near end of ray where there are 5, then 4. In this particular specimen the first 5 or 6 actinal plates carry 2 spines. The first 4 or 5 adambulacral plates carry 2 spines, the next 3 have 3 spines; then over most of the ray there are 4, and near end of ray, again 3. Specimens smaller than the above (Sts. 1562, 1563, WS 825) have 3 adambulacral spines as a rule.

Specimens from the Falkland region, of which the largest measures R 40 mm., r 7 mm., br 8 mm., appear to be typical *scalprifera*.

The scattered crossed pedicellariae which in form and dentation are not peculiar to the genus have small teeth and measure 0.27-0.32 mm. In side view they are rather broadly ovate, the toothed terminal part of jaw occupying one-fourth total length. There are 3 or 4 shank teeth. The lanceolate straight pedicellariae have the tips of jaws slightly crossed and are upward of 0.85 mm. long and 0.35 mm. broad. The great majority are larger than the crossed pedicellariae, whereas in *triremis* the two sorts are subequal. In the actinal interradian areas are 1-4 lanceolate straight pedicellariae similar to the others but larger (1-1.2 mm. long).

DISTRIBUTION. Off Marion Island, 50 fathoms and Heard Island, 75 fathoms; Falkland Islands, 79-267 m.

Smilasterias triremis Sladen

Asterias (Smilasterias) triremis Sladen, 1889, p. 578, pl. 101, figs. 5, 6; pl. 102, figs. 5, 6.

Smilasterias triremis Fisher, 1930, p. 239.

St. 181. Schollaert Channel, Palmer Archipelago, 160–335 m., mud, 2 specimens.

St. 187. Neumayr Channel, Palmer Archipelago, 259 m., mud, 1 specimen.

St. 190. Bismarck Strait, Palmer Archipelago, 93–130 m., rock or stones and mud, 2 specimens.

The smallest specimen measures R 40 mm., r 7 mm., br 8 mm.; the largest measures R 61 mm., r 7 mm., br 8–10 mm. All are therefore larger than the type which has R 35 mm., r 5.5 mm. Treatment with caustic potash reveals a single series of small actinal plates which extend as far as seventh to tenth inferomarginal plate—or about one-fifth length of ray. They are normally spineless but sporadically one of the proximal plates of the series carries a small spinelet. In the largest specimen the first few inferomarginals carry irregularly 2–4 spines; throughout rest of ray, 3 flat, truncate, chisel-shaped spines. In the other specimens there are usually 3, but occasionally 2, spines. The adambulacral plates are diplacanthid as a rule, but here and there a plate with 3 spines occurs. Obviously the actinolateral region is less spiny than in *scalprifera*. Direct comparison of specimens shows that the marginal spines of *triremis* are markedly longer and broader, and the adambulacral spines are longer and more robust than those of *scalprifera*. Dorsally the two species are similar in appearance, actinally very distinct. Attached to the furrow face of the adambulacral plates near base of innermost spine are numerous pedunculate lanceolate straight pedicellariae which, in *scalprifera*, are about 0.6–0.75 mm. long, and, in *triremis*, only 0.25–0.3 mm.

In *triremis* the lanceolate straight pedicellariae which are liberally scattered on the actinal and marginal areas, and more sparingly on the abactinal plates, are subequal in length to the crossed pedicellariae. There are regularly no enlarged pedicellariae in the actinal interradial areas. In *scalprifera* there are conspicuously large lanceolate actinal interradial straight pedicellariae. A definite row of actinal and scattered inferomarginal straight pedicellariae are usually obviously larger than the crossed; very few superomarginal and abactinal straight pedicellariae.

Crossed pedicellariae are similar to those of *scalprifera* and measure 0.27–0.31 mm. in length and 0.18 mm. broad.

The species has heretofore been known only from the type series taken in 150 fathoms, between Kerguelen and Heard Islands, coarse gravel, bottom temperature 35.2 F. Its capture in the Palmer Archipelago indicates that it is an antarctic species, in contrast to *scalprifera* which is subantarctic.

Genus *Cosmasterias* Sladen

Cosmasterias Sladen, subgenus, 1889, p. 576. Type *Asteracanthion sulcifer* Perrier = *A. luridum* Philippi.—Fisher, 1930, p. 227.

Diplasterias Perrier, part, 1891, p. 77.—Meissner, 1904, p. 6.

Comasterias Perrier, 1891, p. 159.

Podasterias Perrier, 1891, p. 160.

Quadraster Perrier, Rés. camp. Prince de Monaco, 1896, p. 27. Type *Stichaster felipes* Sladen.

DIAGNOSIS. Actinal plates in two or more prominent longiseries forming the actinal or the actinal and actinolateral surfaces of ray (and not dominated or overhung by the inferomarginal plates); adambulacral plates diplacanthid, without attached pedicellariae; large unguiculate straight pedicellariae; plates of the abactinal area of ray have the appearance of forming definite longiseries, the carinals and superomarginals being conspicuously regular, and the dorsolateral area generally rather narrow with the plates in discernible longiseries; actinostome sunken, the adoral carina long, consisting of three or more contiguous pairs of adambulacral plates; gonads opening dorsally; not paedophoric.

Southern Hemisphere.

Until this genus is subjected to a revision based upon the study of a thousand or so specimens it will not be possible to determine whether one polymorphic species, or several species inhabit the Magellan-Falkland region.

Cosmasterias lurida (Philippi)

Asteracanthion luridum Philippi, *Arch. Naturges.*, xxiv, 1858, p. 265.

Asteracanthion sucifer Perrier, *Ann. Sci. Nat.*, 1869, p. 235.

Asterias sulcifera Perrier, *Rév. Stell.*, 1875, p. 58.

Asterias (Cosmasterias) sulcifera Sladen, 1889, p. 562.—Leipoldt, 1895, p. 552 (literature list).

Comasterias sulcifera Perrier, 1891, p. 160.

Cosmasterias sulcifera Perrier, 1894, p. 107.

Cosmasterias lurida Ludwig, 1903, p. 40.—de Loriol, 1904, p. 39, pl. 3, figs. 2, 3.—Koehler, 1912, p. 22, pl. 2, figs. 1-7; pl. 5, fig. 8; 1923, p. 39.—Fisher, 1930, p. 227.

To this species Leipoldt, 1895, unites *Asteracanthion clavatum* Philippi, *A. fulvum* Philippi, *A. spectabile* Philippi, *A. mite* Philippi, and *Stichaster polygamus* Sladen.

St. 1902. 49° 48' S, 67° 39' 5' W, 47 m., 1 specimen.

St. WS 78. 51° 01' S, 68° 04' 30" W, 95 m., fine dark sand, 1 specimen.

St. WS 84. 4½ miles south, 9° W of Sea Lion Island, East Falkland Island, 19 specimens.

St. WS 85. 7½ miles south, 9° W of Sea Lion Island, East Falkland Island, 75-74 m., coarse sand, shells, stones, 3 specimens.

St. WS 583. 53° 39' S, 70° 54' W, 14-78 m., 7 specimens.

St. WS 762A. 43° 50' S, 65° 01' 51" W, 67-65 m., 1 specimen.

St. WS 776. 46° 18¼' S, 65° 02½' W, 107-99 m., 5 specimens.

This species has multispinous and paucispinous forms paralleling the behaviour of *Evasterias* and *Pisaster* of the Pacific coast of North America. A very multispinous specimen having an arcuate transverse row of 4 or 5 tubercles on the carinal plates, a similar number on the superomarginals, and consecutive transverse dorsolateral series of 5 or 6, was taken at St. WS 762A. At St. WS 84 were taken paucispinous and intermediate specimens, with 1-3 superomarginal and carinal spines. In one example the spines are small while the unguiculate straight pedicellariae are very numerous. The same variation occurs in *Pisaster brevispinus*, which this specimen superficially resembles (Fisher, 1930, pl. 91, fig. 2, forma *paucispinus*).

It seems to me probable that *Cosmasterias tomidata* Sladen (= *C. germaini* Philippi) is a form of *lurida*.

A specimen from St. WS 78 is labelled "mauve colour dorsally"; while those from St. WS 776 exhibited the following colour range: violet (16), white (7), purple (4), pink orange (3), blue (1).

DISTRIBUTION. Region of the Straits of Magellan and adjacent coasts on both Atlantic and Pacific sides; Tierra del Fuego; South Georgia; low tide to 636 m.

Genus *Granaster* Perrier

Granaster Perrier, 1894, pp. 129, 133. Type *Stichaster nutrix* Studer.—Fisher, 1923, p. 604; 1930, p. 232.

Hemiassterias Verrill, 1914, p. 362, footnote. Type *Granaster biserialus* Koehler.

Granaster nutrix (Studer)

Stichaster nutrix Studer, *Jahrb. wiss. Anst. Hamburg*, 11, 1885, p. 1554, pl. 1, fig. 5a-d; pl. 2, fig. 5e-l.

Granaster nutrix Perrier, 1894, p. 129.—Koehler, 1923, p. 53.

Granaster biserialus Koehler, 1906, p. 11, pl. 1, fig. 6; pl. 4, fig. 42; 1908, p. 565, pl. 5, figs. 48, 49; 1912, p. 29, pl. 3, fig. 2; pl. 6, fig. 1.—Fisher, 1930, p. 233.

Hemiassterias biseriala Verrill, 1914, p. 362.

St. 141. East Cumberland Bay, South Georgia, 17-27 m., 1 specimen.

St. 166. South-east point of Paul Harbour, Signy Island, South Orkneys, shore collecting, 2 specimens.

St. 179. Melchior Island, Schollaert Channel, Palmer Archipelago, 4-10 m., rock, 5 specimens.

St. 1941. Leith Harbour, South Georgia, 55-22 m., 1 specimen.

St. WS 56. Larsen Harbour, Drygalski Fjord, South Georgia, 2 m., kelp roots, 7 specimens.

St. WS 65. Undine Harbour (North), South Georgia, 1 m., kelp roots, 1 specimen.

St. MS 10. East Cumberland Bay, South Georgia, 26 m., 1 specimen.

St. MS 71. East Cumberland Bay, South Georgia, 110-60 m., 1 specimen.

Cumberland Bay. South Georgia, November 1929, 1 specimen.

The largest specimen (St. 166) with R 18 mm. was bright yellow in life.

Koehler (1912) has given good photographic figures. The genus appears to be an isolated one. Possibly it is related to *Calvasterias*.

The species has been reported from South Georgia, South Orkneys, Graham Land, low tide to 250 m.

SPECIES FROM AFRICA AND AUSTRALIA

Astropecten irregularis africanus Koehler

Astropecten africanus Koehler, *Ann. l'Institut Oceanographique*, 11, fasc. 5, 1912, p. 5, pl. 2, figs. 8, 9.

Astropecten irregularis africanus Döderlein, 1917, pp. 47, 73, 168.

St. 299. Tarrafal, San Antonio, Cape Verde Islands, 7-11 m., 1 specimen.

The specimen measures R 28 mm., r 7 mm., R=4r; br at second superomarginal, 7 mm., width of paxillar area 3 mm. Heretofore reported from west coast of Africa 20° to 24° N (Anguin Bank, Cape Blanco, Rio de Oro).

***Astropecten irregularis pontoporaes* Sladen**

Astropecten pontoporaes Sladen, *J. Linn. Soc.*, xvii, 1883, p. 259; 1889, p. 210, pl. 35, figs. 1, 2; pl. 38, figs. 10-12.—Clark, 1923, p. 249.

Astropecten irregularis pontoporaes Döderlein, 1917, p. 75, pl. 1, fig. 5; pl. 7, figs. 9, 9a, 10, 10a.

Astropecten irregularis var. *pontoporaes* Clark, 1926, p. 6.—Mortensen, 1933, p. 232.

St. 91. Simon's Town, False Bay, South Africa, 35 m., 9 specimens.

The specimens range in size from R 9 mm. to R 45 mm. and are typical since they are from the type locality. Colour note: aboral surface pale apricot with pale mauve, a deeper mauve band along centre of rays.

Apparently both Clark and Mortensen regard this as a valid subspecies, which means a geographic race if it signifies anything. May one suggest therefore that it is time to abandon the term "variety" which is often used to name any one of a number of somatic variations that have no geographic or even ecologic implication. For the subspecies the straight trinomial has been in good standing among zoologists for over half a century.

Genus *Luidia* Forbes

Luidia Forbes, *Mem. Wernerian Nat. Hist. Soc.*, viii, 1839, p. 123. Type *L. fragilissima* = *L. ciliaris*, designated, Fisher, 1911, p. 105. See Döderlein, 1920, revision.

Subgenus *Luidia* Forbes

Hemicnemis Müller & Troschel, *Monatsber. Akad. Wiss. Berlin*, April 1840, p. 105. Type *L. ciliaris* (Philippi), designated, Fisher, 1911, p. 105.—Döderlein, 1920, pp. 217, 244.

The citation of a subgenus for the *ciliaris* group of *Luidia* is more to correct an error of Döderlein's than an expression of confidence in the subgenera which he rather lavishly created. When a genus is subdivided, it seems to me axiomatic that the section which includes the original type-species should retain the original name—in this case *Luidia*, and not its obvious synonym *Hemicnemis*.

For the benefit of future workers, and in no way as a criticism of Döderlein's splendid memoir, I wish to record the omission of Goto's¹ two Japanese species, *Luidia yesoensis* (Hokkaido) and *L. moroisoana* (Misaki).

The new species, described below, while resembling *ciliaris* in a general way departs rather radically in having the inferomarginal armature different on alternate plates. The number of rays, 10, is the highest in this section of *Luidia*.

***Luidia heterozona* sp. nov.**

(Fig. M, 4-4c; Plate XXIII)

DIAGNOSIS. Rays 10; rays narrower than in *ciliaris*, the upper inferomarginal spines as long as breadth of abactinal area plus superomarginal plates; inferomarginal spines bristling, 2 and 3 in fairly regular alternation; abactinal, superomarginal, inferomarginal,

¹ Seitaro Goto, A Descriptive Monograph of Japanese Asteroidea, *J. Coll. Sci., Tokyo Imp. Univ.*, xxix, 1914, pp. 301-11.

actinal, and oral bivalved pedicellariae; 3 adambulacral spines in a single transverse series; tube-feet very large; a dark brown superomarginal band; R 115 mm., r 11.5 mm., R=10r; br 8 mm.

DESCRIPTION. Abactinal area of ray narrow, with 3 regular longiseries of circular spaced paxillae on either side, those of the outermost series representing the superomarginals. These, except at base of ray, are very much larger than the adjacent abactinal paxillae, of which 8-12 can be counted across ray to the other superomarginal series. In the median abactinal area (4 paxillae wide at base of ray and 8 at middle) regular longiserial arrangement is lost. The paxillae are stellate, not squarish, well spaced, and decrease in breadth and height very rapidly along ray. At base of ray, the lateral, with 8-12 slender marginal and 1-3 similar central spinelets are obviously larger than the median paxillae; but the disparity becomes rapidly less and less, the lateral-most paxillae become very small and the longiserial arrangement less obvious. The largest paxillae with 10-12 spinelets (and very low tabulum) are now in the central area, intermingled with smaller ones (5-8 spinelets). Many paxillae of disk and proximal third of ray carry a central or marginal conspicuous bivalved pedicellaria (Fig. 4b).

The first 3 superomarginal paxillae are subequal to the lateral abactinal but they rapidly increase in size and the outer margin fuses with the dorsal margin of the inferomarginal. The free border carries 10-12 spinelets and the surface 3-6, of which one, slightly enlarged, constitutes an incipient superomarginal spine. Some of the plates carry a bivalved pedicellaria larger than the abactinal. Corresponding to first 10 superomarginal paxillae are 14 lateral; to the second 10, also 14 lateral.

The inferomarginal plates are heavy, block-like (with deep, wide fascioles), and form a rounded lateral face to ray; that is, they occupy little of the actinal face of ray. At base of ray, the first 6 or 8 are short and wide; width rapidly diminishes so that it is only twice length, and continues until at middle of ray and distally the two dimensions are equal, or the width is slightly the greater. Inferomarginal spines acicular, sharp, bristling. Beginning with second to eighth plate, each alternate plate carries 3 spines. The longest (6-7 mm.) is on the dorsal end and directed upward; the next (5-6 mm.) is on the middle of plate, directed outward or distad; the third (3 mm.) is near lower end, directed downward. Alternating with these (with some interruptions in regularity) are diplacanthid plates; the uppermost spine (subequal to the dorsal of triplacanthid plates) is set slightly above *middle* spine of other plates, while the second (about two-thirds length of upper) is opposite interval between middle and lower spine of triplacanthid plates. The surface of plates has a sparse covering of very delicate ciliary spinelets which become crowded on the transverse margins to cover the fascioles. There is an occasional inferomarginal pedicellaria, similar to abactinal but larger; and smaller than the actinal pedicellariae.

The small actinal plates, in a single series, overlap the outer margin of the adambulacrals and are so strongly joined to the inferomarginals that they appear to be the lower ends of these plates. Each plate is subconical and carries at apex a prominent, lanceolate, two-jawed pedicellaria.

Adambulacral plates block-like, not compressed, except on disk. Each plate carries a transverse series of 3 slender compressed spines, that in furrow the least robust, and most strongly curved; second spine obviously the most robust and slightly longer than the third or outer spine. One or 2 spinelets usually stand adoral to outermost spine.

Mouth-plates very narrow and convex, so that they arch high above the level of disk adambulacrals. The true furrow margin is a short ridge deep in the furrow at inner end of plate. It carries 2 bivalved slender pedicellariae and a slender spinelet which are close to and may touch the broad junction of radial and ring nerve bands. Along the superficial carina of each plate, bordering suture, are 5 or 6 prominent slender tapering blunt spines, the inner almost as long as the plates. They decrease in size from inner to outer which stands one-third plate length from outer end. The outer third of plate carries 5 or 6 superficial spinelets, 5 or 6 along first adambulacral suture margin, and a variously located bivalved pedicellaria.

Papulae (the usual compound sort) are absent from the median area of distal third of ray but appear everywhere else on the abactinal surface. They form three regular longiseries on either side of abactinal area. In a general way their size is in direct relation to that of surrounding paxillae.

Madrepore concealed in smallest specimen but uncovered in the type, broadly elliptical, 2.5 mm. longest diameter, with fine striae radiating from centre.

Colour in alcohol: abactinal surface light brown; dark brown between marginal plates, which are whitish; bases of marginal spines brown.

YOUNG. From St. 279 are 2 specimens having R 26 mm. and R 55 mm. (both with 10 rays). In the smaller the single central spinelet of each ornate paxilla is quite definitely longer and stouter than the peripheral—long enough to be called “enlarged”—especially on the larger lateral and superomarginal paxillae. The spinelets are very delicate and sharp. This disparity in size is less evident in the second, larger, specimen and is lost in the adult (except on superomarginals). The ancestral form may have had well-developed central paxillar spines. Pedicellariae are very rare on the abactinal surface, absent from the mouth-plates, and are present on only the proximal actinals. In place of the two oral pedicellariae at entrance to ambulacral furrow are two co-ordinated spinelets which will develop into the valves of a pedicellaria as, in one instance, the differentiation is under way.

The inferomarginal armature lacks the lowest spine of the triplacanthid plates. There are thus 2 spines to a plate on proximal two-thirds of ray but with the differentiation shown on the adult—the dorsal spine of alternate plates is close to the upper margin. Distally the lower spine of the diplacanthid plates of the adult is lost so that the major spines are 2, 1, 2, 1. This is true also of the second specimen.

In the second specimen the first half dozen superomarginals may carry a pedicellaria, the actinal pedicellariae extend to about the middle of ray, and a large oral pedicellaria is present at mouth of furrow, definitely a development of the 2 spinelets of the small specimen. A suboral pedicellaria is present on some but not all plates and there are

three instead of five major suboral spines. The single series is continued from middle to outer end of plate by 5 smaller spinelets, or 3 spinelets and the pedicellaria just mentioned.

TYPE LOCALITY. St. 272. Off Elephant Bay, Angola, 73–91 m., 1 specimen.

SPECIMENS EXAMINED. The type and 2 from St. 279, off Cape Lopez, French Congo, 58–67 m.

REMARKS. This species seems to be definitely in the *ciliaris* group on account of the superomarginal plates abruptly larger than the adjacent lateral paxillae and the squarish block-like inferomarginals. The regular alternation of 2 and 3 long lateral spines is highly characteristic. The mouth-plates, however, are very convex and the presence of 2 pedicellariae near the inner end, deep in furrow, is similar to the condition in *L. avicularia* (subgenus *Integraster* Döderlein, 1920, p. 243, fig. 19).

This species is related to *L. aciculata* Mortensen but not closely to any other in the *ciliaris* group.

Luidia aciculata Mortensen

(Fig. M, 5)

Luidia aciculata Mortensen, *Echinoderms of St Helena*, 1933, p. 425, text-fig. 7, pl. 20, figs. 7–12.

St. 279. Off Cape Lopez, French Congo, 58–67 m., 1 specimen.

This specimen was dredged along with the two smaller examples of *L. heterozona*, and is not fully grown since the dimensions are R 45 mm., r 6 mm., br 7 mm. The longest arm fragment of type is 130 mm. and the broadest, 12 mm. The specimen agrees in most details with Mortensen's description and line figures. The paxillae, devoid of pedicellariae, all have the enlarged central spinelet. There are 1 or 2 conspicuous, conical tri-valved actinal intermediate pedicellariae. The mouth-plates have 2 spinelets at inner end, close to nerve ring, co-ordinated into a simple pedicellaria; there is a very slender spinelet adoral to the outer and smallest of the 3 adambulacral spines; the actinal plates bear a group of usually 3 spinelets.

Mortensen's description reads: "Inferomarginals with 3, in the proximal part some of them with 4 large, erect, cylindrical, pointed spines, the uppermost the longest." In the Discovery specimen the first plate is very compressed with 3 smallish ventral spines, the lowest the largest; second plate with 4 larger spines, the upper very much larger, and equal to the succeeding ones; third plate, 3 spines, the upper normal, the 2 lower larger than the 3 of second plate. From here on there are 2 large spines on each plate; but on alternate plates the pair has moved downward so that the dorsal spine is removed from upper end of plate and stands out of line, as does the lower with the corresponding spine of adjacent plates, precisely as in the diplacanthid plates of the 2 specimens of *L. heterozona* from St. 279.

This difference in the position of spines may be accentuated in young specimens and therefore may have escaped notice in larger examples. The peculiarity points to a closer relationship between *aciculata* and *heterozona* than between either of these species and any other in the *ciliaris* group. Even the mouth-plates with the furrow pedicellaria are

closely similar, while it will be recalled that young *heterozona* have the central paxillar spinelet larger than the peripheral. In *aciculata* the superomarginal paxillae are essentially as in *heterozona* with the outer margin fused with the upper end of the inferomarginal. This takes place, of course, in *ciliaris* also.

Ophidiaster guildingii

Ophidiaster guildingii Gray, *Ann. Mag. Nat. Hist.*, 1840, vi, p. 284.—H. L. Clark, *Echinoderms of Torres Strait*, 1921, pp. 78, 79.

St. 1. Clarence Bay, Ascension Island, 16 November 1925, 16–27 m., 2 specimens.

The larger specimen has R 24 mm., r 4.5 mm. and conforms to Clark's characterization of *O. guildingii*, rather than to *O. ophidianus*.

Genus Patiria Gray

Patiria Gray, *Ann. Mag. Nat. Hist.*, vi, 1840, p. 290. Type *Patiria coccinea* Gray = *Patiria miniata* (Brandt) *fide* Mortensen, 1933, p. 257.—Fisher, 1908, p. 90.—Verrill, 1913, p. 482.

Callopatiria Verrill, 1913, p. 480. Type *Patiria bellula* Sladen.

Not *Patiria* Perrier nor of Sladen. *Asterina*, in part, of authors.

Mortensen's discovery (1933, p. 257) that Gray's *Patiria coccinea* was based upon specimens of *P. miniata* with erroneous label is substantiated by his photograph of one of the types. Even if this type should prove to be the Japanese *P. pectinifera* it will make no difference as the two species are closely related.

This genus contains usually large species characterized by having numerous small secondary plates inserted peg-like in the papular areas. They form a sort of small secondary mesh between the primary plates and serve to isolate the numerous papulae of the areas formed by the primary plates. A good enlarged photographic figure is given in my *Asteroidea of the North Pacific* (1911, pl. 62, fig. 1; see also pl. 56, fig. 8a for plan of primary plates). The primary plates of the papular area overlap by their corners, the amount of imbrication depending upon age of specimen and position of plate, those in the median radial region overlapping less than on the lateral parts of ray.

The secondary plates or ossicles do not extend, as a rule, through to the coelomic surface of the body wall. Each bears a group of spinelets.

In *Patiria* the gonads open dorsally and the eggs develop into a pelagic *Bipinnaria*.¹

Patiria bellula Sladen

Patiria bellula Sladen, 1889, p. 385, pl. 63, figs. 1, 2; pl. 64, figs. 5, 6.—Koehler, 1908, p. 632.

Asterina coccinea Bell (not of Gray), *Marine Investigations S. Africa*, 1905, p. 248.

Callopatiria bellula Verrill, 1913, p. 480.

Parasterina bellula H. L. Clark, 1923, p. 280.—Mortensen, 1933, p. 260.

St. 91. Simon's Town, False Bay, South Africa, 1 specimen, deep orange.

Saldanha Bay, South Africa, 1926, beach, 1 specimen.

¹ Figured by Mortensen, 1921, *Studies of the Development and Larval forms of Echinoderms*, p. 186, pl. 33, figs. 1, 2, *Patiria pectinifera*.

An examination of the skeleton of the larger specimen (R 40 mm.) reveals that it differs from that of *Patiria miniata* only in the presence, on the primary plates, of hyaline convexities. These are the surface ends of what appear to be hyaline cylinders descending into the matrix of the plate. The primary plates overlap by the lobes or corners and the papular areas are occupied by small secondary plates as in *P. miniata*.

NOTE ON *PARASTERINA* FISHER

It is curious that *Patiria bellula* again becomes known by the combination which Sladen originally used. Sladen's *Patiria* was not Gray's. It was a group, originating with Perrier (1875, p. 323), which omitted Gray's type, and comprised 2 species, *P. ocellifera* Gray and *P. crassa* Gray. This genus, not the original *Patiria*, was named *Parasterina* by me (1908, p. 90), with *P. crassa* Gray the type. Justification for the genus lay in Perrier's statement that, in *crassa*, the dorsal ossicles are rounded, nearly circular, and are not imbricated as ordinarily the case in *Asterina*, but touch one another. This statement is repeated in Sladen's key to the genera of Asterinidae (1889, p. 276).

Through the kindness of Dr H. L. Clark I have received a specimen of *Parasterina crassa*, from near Fremantle, Western Australia.¹

This specimen has R 45 mm., r 10 mm., br 11–12 mm., and the abactinal aspect resembles superficially that of *Nardoa variolata*, as the convex primary plates are spaced and the spinelets extremely fine, close-set, and visible only under strong magnification. The species is quite unlike a true *Patiria* but resembles *Nepanthia*. In fact, the actinal surface does not differ from that of *Nepanthia* (e.g. *N. belcheri*) in any important particular. The actinal plates are covered with co-ordinated groups of very numerous spinelets. There are 15–18 similar subambulacral spinelets, and 8 or 9 furrow spinelets. The inner longiseries of actinal plates extends to 3 or 4 inferomarginals short of the end of ray; the next two series nearly as far; the fourth series about three-fifths length of ray measured on side; while a fifth and sixth series constitute a small additional chevron in the interbrachial angle.

The two series of marginal plates are quite regular, and correspond, plate to plate; they are obviously larger than the adjacent abactinals and actinals, which are small.

There are two differentiated areas on the abactinal surface. (1) A lateral triangular area reaching, at interradius, one-half of r toward centre of disk and distally nearly half length of ray; from this point it extends usually as a double series of plates nearly to tip of ray. The plates of this area, in regular longiseries, strongly imbricate, and the upper margin is excavated to accommodate a papula. Around this papular opening are 2–4 small superficial plates. Nearly all the plates carry a spiniform pedicellaria. (2) The other area, that of the convex primary plates, comprises the central part of disk and rays. It broadens distally to include most of the sides of ray also. The roundish and irregular, convex, almost tubercular primary plates for a short distance at base of ray imbricate irregularly but over rest of area are joined by smaller and lower secondary plates. These

¹ Clark, H. L., Echinoderms from Australia, *Mem. Mus. Comp. Zool.*, LV, 1938, pp. 179–181.

are irregular in shape and imbricate irregularly. Sometimes the end of these plates extend under the large primaries, sometimes they slightly overlap their edges—in short, imbricate. Very many small superficial tertiary plates of variable size fortify the joints of the primaries and secondaries and help to define the papular pores. These are the same as the superficial platelets of lateral area.

The exposed surface of the plates is covered by a multitude of very small spinelets with microscopically thorny tips (length 0.22–0.28 mm.) of nearly uniform thickness (0.04–0.05 mm.) on the secondary and tertiary plates, but, more robust (0.08–0.12 mm.) on the centre of the primaries.

The pedicellariae of the lateral abactinal plates are rather remarkable. There is a conspicuous pit usually near or at the upper excavate margin of plate. Extending over this are 5–8 minutely thorny, sharp spinelets tapering from a rather broad base and conspicuously larger than the other spinelets of plate. They form a U-shaped series or sometimes a circle, and resemble the circular spiniform pedicellariae of the Benthopectinidae. The pits probably contain a sense organ.

I find precisely similar pedicellariae in *Nepanthia variabilis*¹ Clark from Broome, Western Australia. Nearly every plate of the lateral areas is provided with one, and a scattering of the larger crescentic plates of the abactinal area are similarly armed.

The adambulacral, actinal, and the lateral abactinal plates of *Parasterina crassa* are in no way different from those of *Nepanthia*. This leaves only the enlarged plates of the median abactinal area with the numerous intervening secondary plates and superficial tertiary plates upon which to base a new genus. But *Parasterina occidentalis* Clark (1938, p. 180, pl. 21, fig. 5) has no secondary abactinals. It is questionable, therefore, whether we can place too much reliance for generic characters upon these median abactinal plates. The behaviour of the abactinal plates of *Nardoa* furnishes reason for caution. In *N. pauciforis* the plates are numerous, small and most nearly uniform in size. Somewhat larger and progressively more diverse as to size are those of *N. mollis*, *N. tuberculata* and *N. novae-caledoniae*; while in *N. tumulosa* and *N. frianti* the large primary plates are hemispherical and the secondaries small and much more numerous (Fisher, 1919, pls. 108–110). The possibility must be considered that in *Nepanthia* aberrant species exist with over-developed primary abactinal plates. It is not a rare occurrence in the Asteroidea, and in certain species of the Asteriidae (e.g. *Leptasterias polaris*, *Pisaster ochraceus*) is of less than specific value. Both *Parasterina crassa* (Gray) and *P. occidentalis* Clark must be regarded with suspicion. I think the former is an aberrant *Nepanthia*.

Patiria granifera Gray

Patiria granifera Gray, *Proc. Zool. Soc. Lond.*, 1847, p. 82, Synopsis, 1866, p. 17.

Asteriua granifera Perrier, 1875, p. 319.—H. L. Clark, 1923, p. 281, pl. 17, figs. 1, 2.—Mortensen, 1933, p. 256.

St. 90. Simon's Town, False Bay, South Africa, 2–10 fathoms, 2 specimens (R 50 and 55 mm.).

¹ Clark, 1938, p. 176, pl. 10, figs. 4, 5; pl. 20, figs. 4, 5.

The skeleton is like that of *P. bellula* and there are the same hyaline beads on the surface of the primary plates. The two forms are so close that I think there is no escaping Mortensen's conclusion that we are dealing with one variable species.

Patiriella exigua (Lamarck)

Asterias exigua Lamarck, 1816, III, p. 554.

Asterina exigua Perrier, 1875, p. 302.—Clark, 1923, p. 285.

Patiriella exigua Verrill, 1913, p. 484.—Fisher, 1919, p. 416, pl. 109, figs. 3, 4.

Asterina (Patiriella) exigua, Mortensen, 1933, p. 252, pl. 12, figs. 4-8.

Saldanha Bay, beach, 1926, 3 specimens.

St. 271. Elephant Bay, Angola, 30 July 1927, shore, 3 specimens.

Henricia ornata (Perrier)

Echinaster ornatus Perrier, *Ann. Sci. Nat.*, sér. 5, XII, 1869, p. 251.—Mortensen, 1933, p. 263.

Cribrella ornata Perrier, 1875, p. 112.—Sladen, 1889, p. 543.—Koehler, 1908, p. 629, pl. 12, figs. 105-106.

Henricia ornata Döderlein, 1910, p. 252, pl. 4, figs. 2, 2a.—Clark, 1923, p. 289.

Saldanha Bay, Cape of Good Hope, beach, 2 specimens.

Mortensen (*loc. cit.*) states: "It is perfectly evident that this species is not a *Henricia* since it has no papulae on the oral side." But *Echinaster reticulatus* H. L. Clark, listed on the following page, has actinal papulae right up to the adambulacral plates (Clark, 1923, pl. 291). *Echinaster* in the restricted sense lacks actinal papulae. *Othilia* Gray, usually merged with *Echinaster*, has actinal papulae.

But *ornatus* resembles *Henricia* more than it does *Echinaster*. Its relationship to typical *Henricia* is that of *Echinaster*, *s.s.*, to *Othilia*. If one recognizes this distinction between the two sorts of *Echinaster* he is probably justified in doing the same for the two categories of *Henricia*.

One of the principal distinctions between *Echinaster* (plus *Othilia*) and *Henricia* (including *ornatus*) is the structure of the adambulacral armature. In *Echinaster* there is an unbroken web along the furrow margin uniting successive *innermost* subambulacral spines (not the spinelets deep in furrow). Sometimes this web is thin and much retracted, especially in dried specimens; sometimes it is thick, almost leathery, as in *E. callosus*. It is emarginate between the spines giving a serrate border to furrow. The spines and membrane may be directed over the furrow, and interlock with the spines of opposite side.

Henricia entirely lacks this web. The marginal spine, or spines, of any adambulacral plate are completely independent of those of adjacent plates.

The gonads of *Henricia* open on the actinal surface—as do those of *Othilia*, at least.

In the two dried specimens of *H. ornata* the gonopores are clearly visible—two in each actinal interradial area.

Coscinasterias calamaria (Gray)(Fig. L, 5, 5*b*)*Asterias calamaria* Gray, 1840, p. 179.*Coscinasterias calamaria* Perrier, 1894, p. 106.—Fisher, 1928, p. 128.—Clark, H. L., 1938, p. 189.

St. 1686. Port Philip, Victoria, Australia (piles of Queen's Cliff Jetty), 1 specimen.

A wide ranging, variable species. The specimen has 9 rays and R 35 mm.

Marthasterias glacialis forma *rarispina* Perrier*Asterias rarispina* Perrier, 1875, p. 62.*Marthasterias rarispina* Clark, 1923, p. 305.*Marthasterias glacialis* var. *rarispina* Mortensen, 1933, p. 273, pl. 16, figs. 2, 3.

St. 90. Simon's Town, False Bay, South Africa, 2–10 m., 7 specimens.

St. 91. Same locality, 35 m., 4 specimens.

The largest specimen has R 95 mm. All are the extreme form, without dorsolateral spines, similar to Mortensen's fig. 2.

A colour note to St. 91 reads: "lilac with apricot spines". One wishes for a colour plate!

The multispinous form, *africana*, figured by Mortensen, is not present in the collection, although I have seen it. Such variation in the number of spines is similar to the condition found in *Pisaster giganteus* and *P. brevispinus* of California.

When adequate material has been compared, I believe that a small but constant difference will be found between typical north European specimens and those from South Africa. One distinction may be a small average difference in the size of the crossed pedicellariae. I have followed Mortensen's nomenclature for the sake of stability, but I think the South African form will eventually be *Marthasterias glacialis africana* (Perrier) with forma *africana*, forma *rarispina*, and probably others if one cares to name them.

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NOTE: All line figures are five-sixths the stated enlargement on account of necessary reduction of original plates.

Fig. A

1. *Perknaster fuscus*, cotype. Spinelets of abactinal paxillae from ray, 0.54 and 0.55 mm., $\times 100$. 1*a*. Abactinal spinelet, base of ray, 0.55 mm., $\times 100$. 1*b*. Actinal intermediate spinelet, 0.65 mm., $\times 100$. 1*c*. Inferomarginal spinelet, 0.54 mm., $\times 100$. 1*d*. Abactinal spinelet from near end of ray, 0.45 mm., $\times 100$.
2. *Perknaster fuscus*, cotype. Profile of abactinal paxillae, pedicel 0.22 mm. high, $\times 50$. 2*a*. Larger abactinal plate, $\times 50$. 2*b*. Small paxilla pedicel 0.18 mm. high, $\times 50$. 2*c*. Side view of abactinal plate with pedicel, 0.22 mm. high, $\times 50$. 2*d*–2*f*. Three adambulacral spines from near proximal end of furrow, 1.7, 1.4 and 0.85 mm. respectively, $\times 40$. 2*g*. Tip of 2*f*, $\times 100$.
3. 3*a*. *Perknaster densus*. Two abactinal plates, base of ray, seen from side, pedicel 0.45 mm. high, $\times 50$. 3*b*. Two abactinal spinelets proximal third of ray (from plates 3, 3*a*), 0.48 and 0.45 mm. long, $\times 100$. 3*c*. Spine from actinal interradiar area, 0.58 mm. long, $\times 100$. 3*d*. Adambulacral plate, mouth toward right, and furrow spines on lower side of figure shown extended over furrow, $\times 15$. 3*e*. Four of 8 adambulacral spines of seventh plate, the longer spine from each of the 4 longiseries, $\times 30$: *a*, aboral furrow spines, 2 mm.; *b*, adoral of second row, 1.5; *c*, adoral of third row, 0.93 mm.; *d*, adoral of outer row, 0.8 mm. 3*f*. Adambulacral armature of a seventh plate seen from oral side, the spines erect and closely apposed as is usual in this specimen.
4. *Perknaster fuscus*, cotype. Fourth to sixth adambulacral plates; lowest plate the fourth, $\times 20$.

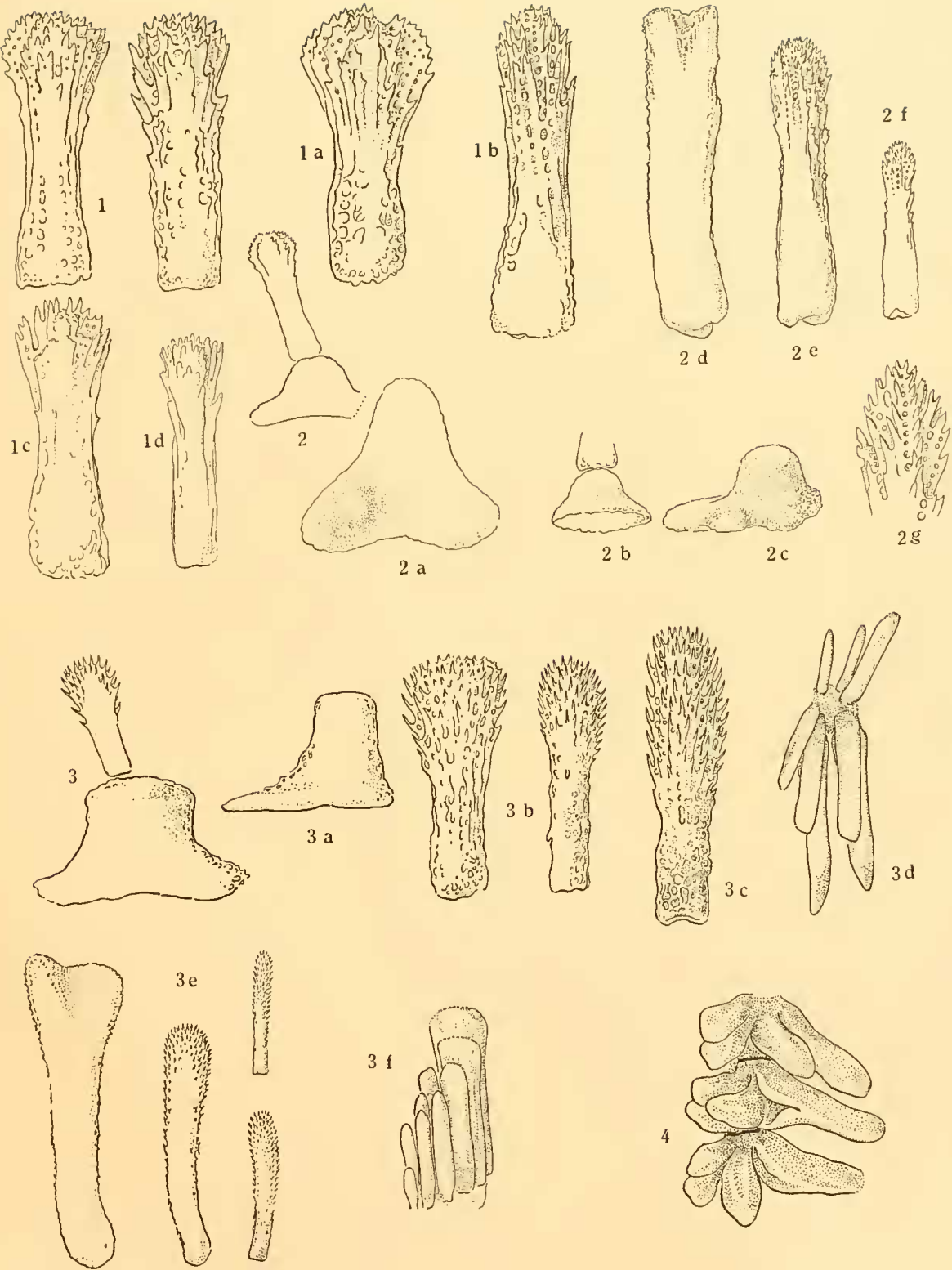


Fig. B

1. *Perknaster fuscus antarcticus*, St. 181. Abactinal spinelet, 0.5 mm. long, $\times 100$. 1*a*. Profile of an abactinal paxilla; pedicel 0.2 mm. high, $\times 50$.
2. *Perknaster sladeni georgianus*, St. 42. Abactinal spinelet, 0.54 mm. long, $\times 100$. 2*a*. Actinal spinelet, 0.72 mm., $\times 100$. 2*b*. Profile of abactinal paxilla; pedicel 0.4 mm., $\times 50$.
3. *Perknaster sladeni*, Shag Rocks. Abactinal spinelet, 0.6 mm. (to 0.7 mm.), $\times 100$. 3*a*. Actinal spinelet, 0.86 mm., $\times 100$. 3*b*. Two adambulacral furrow spinelets, 2.2 and 2.7 mm., $\times 25$. 3*c*. Profile of abactinal paxilla; pedicel 0.54 mm., $\times 50$.
4. *Perknaster sladeni*, St. 182. Two abactinal spinelets, 0.65 and 0.67 mm., $\times 100$. 4*a*. Profiles of 2 abactinal paxillae; pedicels 0.5 and 0.46 mm., $\times 50$. 4*b*. Normal actinal spinelet, 0.8 mm., $\times 100$. 4*c*. One of the 3 valves of an actinal pedicellaria, 0.66 mm., $\times 100$.
5. *Perknaster charcoti*. Profile of paxilla of large specimen C, pedicel 0.62 mm., spinelets 0.74 mm., $\times 50$. 5*a*. Abactinal spinelets of small specimen B, 0.53 and 0.63 mm., $\times 100$. 5*b*–5*d*. Specimen B, profiles of 3 paxillae, pedicels 0.45, 0.36, 0.45 mm., $\times 50$. 5*e*. Actinal spine of large specimen C, 1.7 mm., $\times 50$.

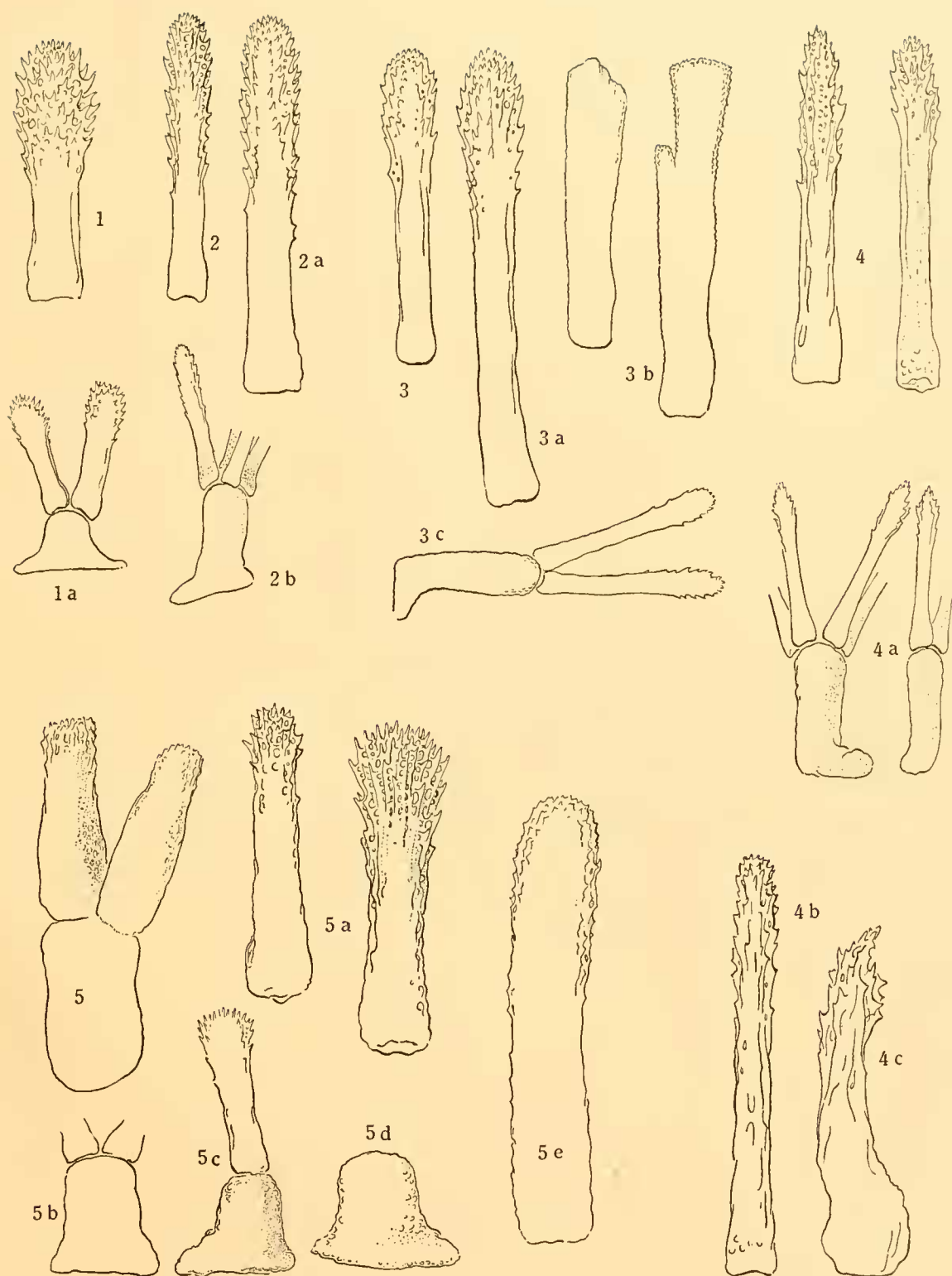


Fig. C

1. *Perknaster aurorae*, small specimen (R 40–50 mm.), St. 371. Abactinal spinelet, 0.63 mm., $\times 100$. 1a. Actinal spinelet, 0.7 mm., $\times 100$. 1b, 1c. Profiles of abactinal paxillae, 0.32 and 0.22 mm. high; 1c is a secondary plate.
2. *Perknaster aurorae*, large specimen, St. 366. Abactinal spinelet, 1.5 mm., $\times 50$. 2a. Enlargement showing spicules beginning to degenerate.
3. 3a. *Perknaster aurorae*, “aberrant” specimen, St. MS 71. Two abactinal spinelets, 0.63, 0.55 mm., $\times 100$. 3b. Actinal spinelet, forming part of a pedicellaria, 0.8 mm., $\times 50$. 3c. Tip of 3b, $\times 100$. 3d. Profile of an abactinal paxilla, pedicel 0.5 mm. (varying to 0.45 mm.); spinelet 0.68 mm., $\times 50$.
4. *Cycethra verrucosa*, abactinal spinelets from various specimens, $\times 100$. 4a. Specimen (R 25 mm.) from St. M 71, South Georgia; spinelet 0.35 mm. 4b. St. 160. Shag Rocks; R 15 mm., 0.27 mm. long. 4c. St. 167. South Orkneys; R 44 mm., 0.45 mm. long. 4d. St. 123. South Georgia; R 75 mm., largest of the Antarctic forms; 0.45 mm. long. 4e, 4f. St. 170. Marginal plates not superficially distinguishable from abactinal or actinal plates; R 41 mm.; spinelets 0.45 and 0.38 mm. long. 4g. St. 55. Falkland Islands; specimen with slender rays and small marginals similar abactinally to Koehler, 1923, pl. 7, figs. 5, 11, but forma *electilis* actinally.
5. *Peribolaster folliculatus*, $\times 10$. Three adambulacral plates, near base of ray with ankylosed inferomarginals, and 3 superomarginals (*S*) on right; *A* 12–*A* 14, adambulacral plates 12–14, the fourteenth divided as happens sporadically; *I*, inferomarginal plates with the single long spine; lowermost plate is cross-lined to show its extent but there is no line of demarcation in the specimen. The broken line crossing the adambulacral marks portion of inferomarginal fused to upper surface of adambulacral, which was identified in a smaller specimen from St. WS 93.

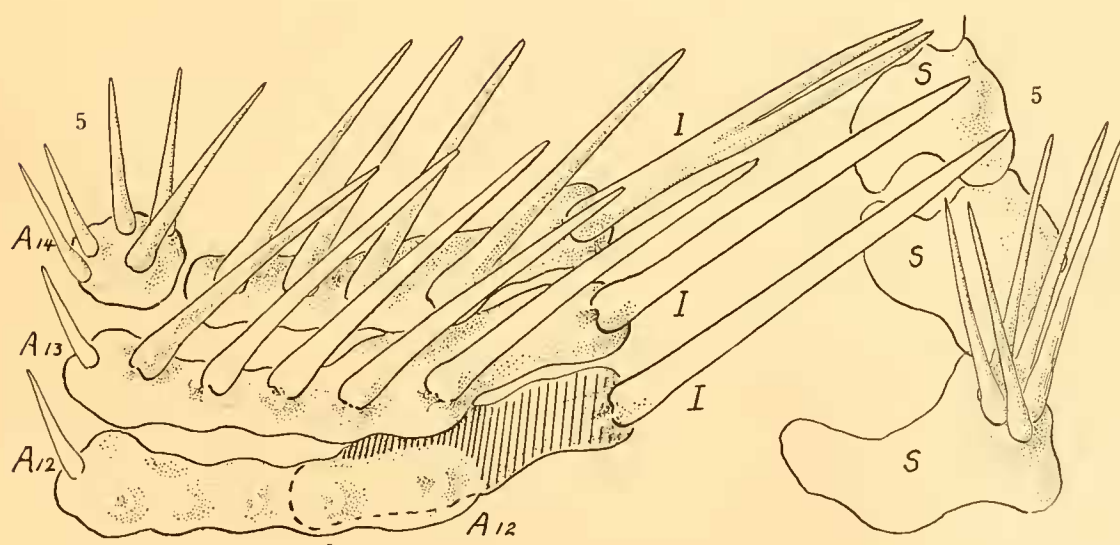
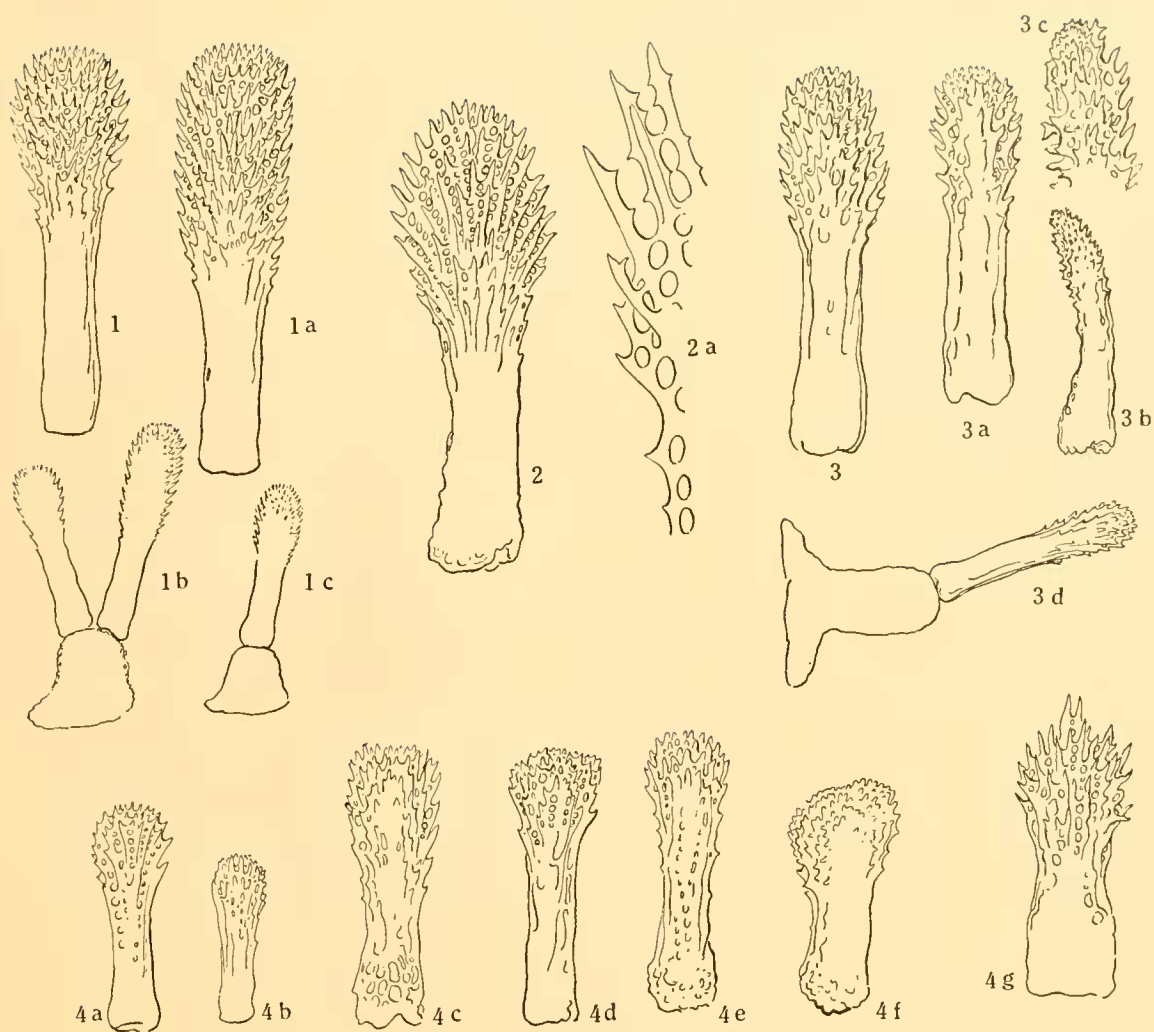


Fig. D

1. *Notioceramus anomalus*, $\times 10$. Plan of abactinal plates of proximal radial region: *C-C*, radial line; papulae shown as large spots. 1*a*. Adambulacral furrow spines, 1.7 mm. long, $\times 25$. 1*b*, 1*c*. First and second subambulacral spines, $\times 25$; 1*b* is 1.5 by 0.85 mm.; 1*c* is 0.85 by 0.5 mm. 1*d*. Three abactinal granules, 0.29, 0.32 and 0.51 mm. high. 1*e*. Second and third (lower) adambulacral plates, and an actinal plate (*AC*) carrying a 3-valved pedicellaria, $\times 15$. The subambulacral spines of second plate are much foreshortened.
2. *Cladaster analogus*, 2 actinal pedicellariae; left open, 1 mm. wide, 0.9 mm. high, $\times 20$; right, closed, $\times 40$.
3. *Kampylaster incurvatus*, abactinal spinelet 0.18 mm. high, $\times 200$. 3*a*. Another spinelet, 0.23 mm., $\times 100$. 3*b*. Abactinal spinelet of young specimen, 0.1 mm. high, $\times 200$. 3*c*. Spinelet from third marginal plate, 0.39 mm., $\times 200$. 3*d*. Actinal spinelet, 0.54 mm., $\times 100$.
4. *Mirastrella biradialis*, side view of ray, $\times 12$, to show plates: *AD*¹, *AD*², adradials; *I*, primary interradials; *IN*, inferomarginals; *R*, primary radial, *r*¹, *r*², the 2 series of radials; *S*, superomarginals; *T*, terminal. 4*a*. Abactinal "granule" or spinelet, 0.15 mm. long, $\times 200$. 4*b*. Inferomarginal spinelet, 0.27 mm. long, $\times 100$. 4*c*. Abactinal spinelet to same scale, $\times 100$. 4*d*. First and second inferomarginals and adjacent adambulacral plates, $\times 30$; *a-a*, 2 groups of 3 actinal spinelets. 4*e*. Map of abactinal plates, $\times 15$, the marginals omitted on lower side; *C*, central plate; *x*, adcentral end of interrarial groove; superomarginals dotted.

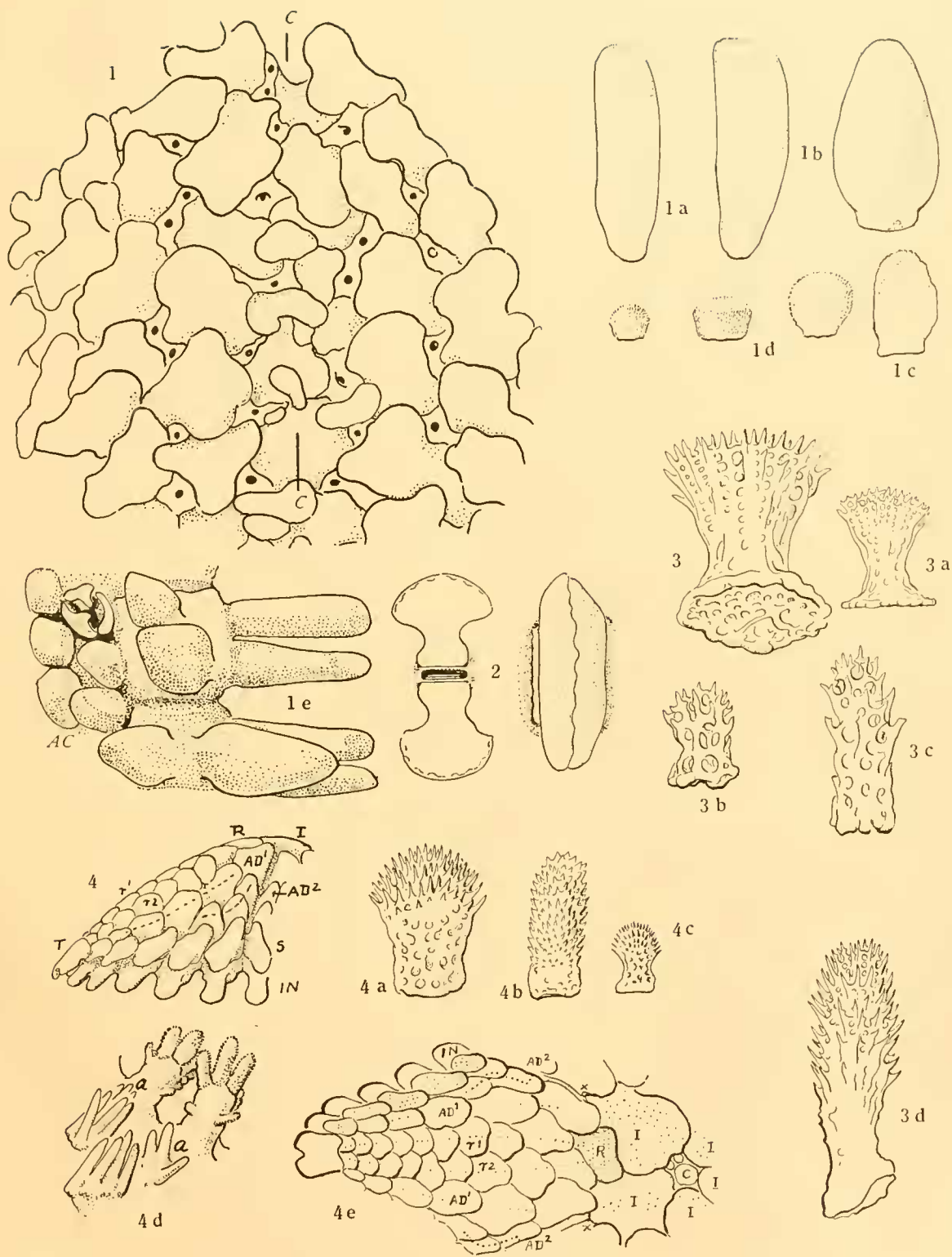


Fig. E

1. *Anseropoda antarctica*; an abactinal granule 0.18 mm. long, $\times 200$. 1a. Dorsolateral plates adjacent to adradials (*AD*) seen from coelomic side, $\times 30$. 1b. One of the dorsolateral plates to show internal process, $\times 40$. 1c. Actinal spinelet, 0.37 mm., $\times 100$.
2. *Rhopiella koehleri*; primary abactinal spinelet, 1.2 mm. long, $\times 50$. 2a. Secondary abactinal spinelet, 0.9 mm. long, $\times 50$. 2b. Terminal part of a primary spine, $\times 100$. 2c. Sixth adambulacral plate of type showing adoral face of web, furrow on right, $\times 20$; *AC*, actinal spine. 2d. Excised adambulacral plate, adoral face showing relation of spines to the web.
3. *Lophaster stellans*, St. 81; superomarginal spinelet 1.25 mm. long, $\times 100$. 3a. Three abactinal paxillar spinelets, 0.85, 0.7, 0.86 mm. long, $\times 100$.
4. *Lophaster densus*; abactinal spinelet 0.34 mm., $\times 100$. 4a. Concave side of tip of an abactinal spinelet, $\times 200$. 4b. Largest and smallest inferomarginal spinelets of same paxilla (0.63 and 0.32 mm.), $\times 100$. 4c. Inner subambulacral spinelet at base of ray, 1.17 mm. long, $\times 50$.

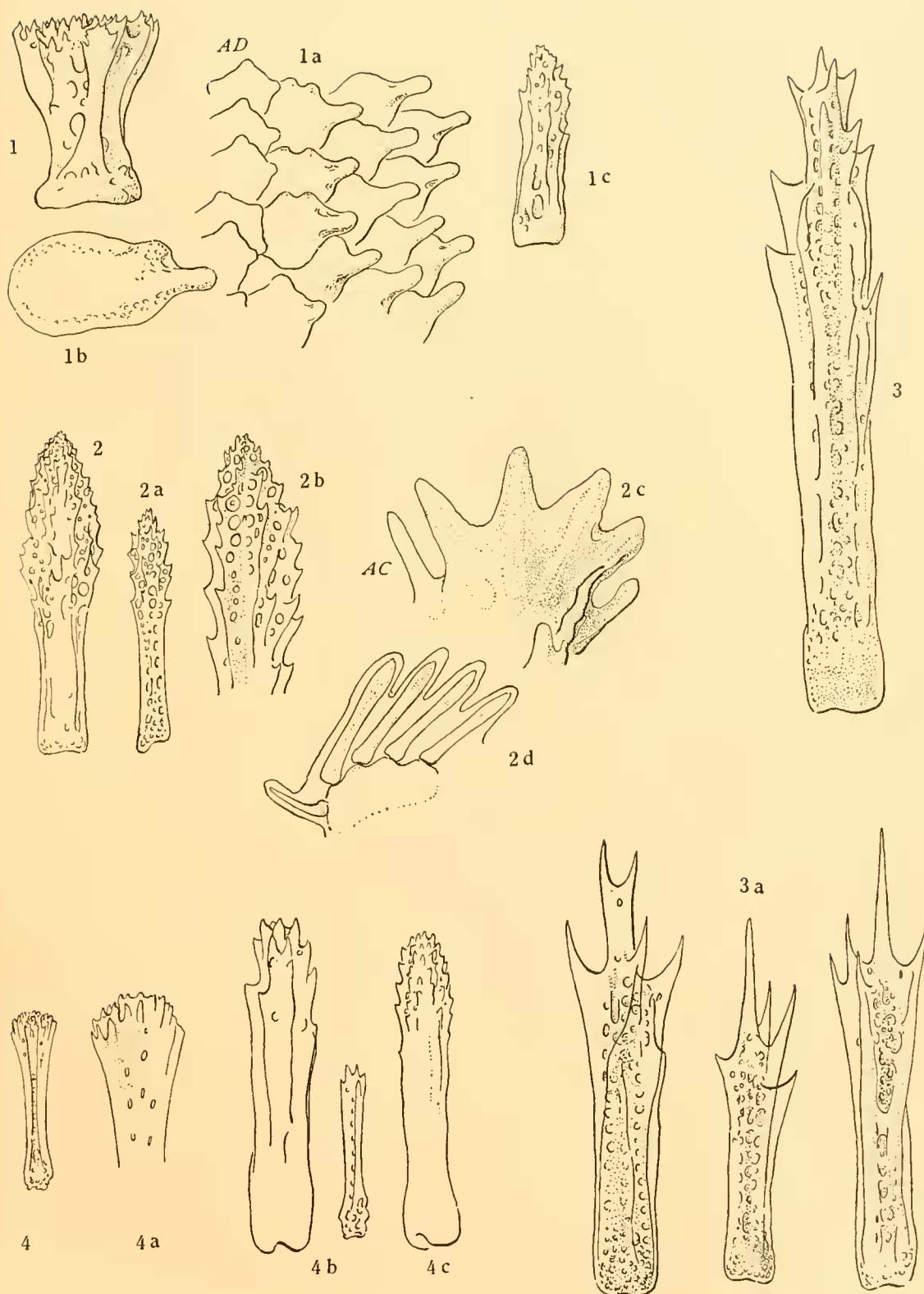
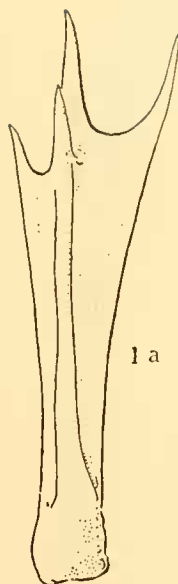


Fig. F

1. *Lophaster marionis*, type; 2 abactinal spinelets, 0.8 and 0.83 mm. long, $\times 100$. 1*a*. Type, inferomarginal spinelet, 0.9 mm., $\times 100$. 1*b*. St. WS 81; inferomarginal spinelet, 1.05 mm., $\times 100$. 1*c*. Inner subambulacral spinelet, base of ray, 1.8 mm., $\times 50$. 1*d*. Outermost subambulacral, same series as 1*c*, 1.5 mm. long, $\times 50$.
2. *Paralophaster godefroyi meseres*; 2 abactinal spinelets 0.9 and 1 mm. long and ends of 2 others, $\times 100$. 2*a*. Inferomarginal spinelet, 1.4 mm. long and tip of another, $\times 50$. 2*b*. Subambulacral spinelet 1.8 mm. long, and 2 tips, $\times 50$.
3. *Pedicellaster hypernotius*, $\times 200$. An abactinal pedicellaria (0.225 mm. long, St. 160) between single jaws of actinal pedicellariae; left, St. 160, 0.4 mm. long; right, St. 190, 0.38 mm.
4. *Anteliaster scaber*, St. 1563; abactinal pedicellaria 0.2 mm. long. 4*a*. Two abactinal spinelets, 0.38 and 0.31 mm.



1



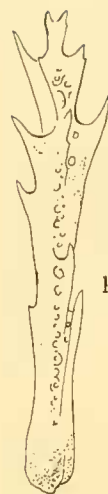
1 a



1 b



1 c



1 d

2



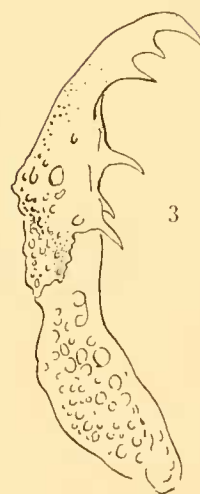
2 a



2 b



3



3



4



4 a



Fig. G

Odinella nutrix

1, 1*a*. Disk spinelets from immature specimen, St. 123 (pl. XVII, fig. 2), having extreme diameter of 34 mm., $\times 100$. Fig. 1, 0.57 mm. long, is one of the long-pronged spinelets found only on disk. 1*a*. 0.6 mm. long. 1*b*. St. WS 766. Disk spinelet of immature specimen, 0.63 mm. long.

2-2*c*. Disk spines of adult specimens $\times 100$; 2, St. 123, 1 mm. long, the same sort being found on the type; 2*a-b*, pronged spines from type, St. 39, 1.08 and 0.95 mm. long; 2*c*, tip of spine, type. 2*d*. Abactinal spine from genital inflation of type, 1.53 mm. long, $\times 50$. 2*e*. Sixth inferomarginal spine of type, 2.5 mm. long, $\times 50$.

3-3*c*. Young in stage 4 from brood pouch. 3. Abactinal plate, 0.45 mm. in diameter, $\times 50$; 3*a*, abactinal spinelet, $\times 50$; 3*b*, abactinal spinelet, 0.36 mm. long, $\times 100$; 3*c*, adambulacral spinelet, 0.4 mm. long, $\times 100$.

4-4*d*. Young in stage 1 from brood pouch, St. 123. Fig. 4, abactinal, diameter 2.55 mm., $\times 20$. 4*a*, actinal view of 3 rays, $\times 30$; 4*b*, an embryonic abactinal plate, 0.2 mm. in diameter, $\times 100$; 4*c*, 4*d*, abactinal spinelets, 0.15 and 0.12 mm. long, $\times 200$.

5, 5*a*. Pedicellariae from lateral spine of type, middle of ray, 0.135 mm. high, $\times 300$; 5*a*, inner face of jaw tip; 5*b*, middle piece.

6-6*b*. Pedicellariae from marginal mouth spines of type, $\times 300$; 6, detail of jaw tip; 6*a*, back view to show the flaring "handles" of the blades or jaws; 0.16 mm. high (*mp* = middle piece); 6*b*, profile view showing numerous excessively fine shank teeth, height 0.18 mm.

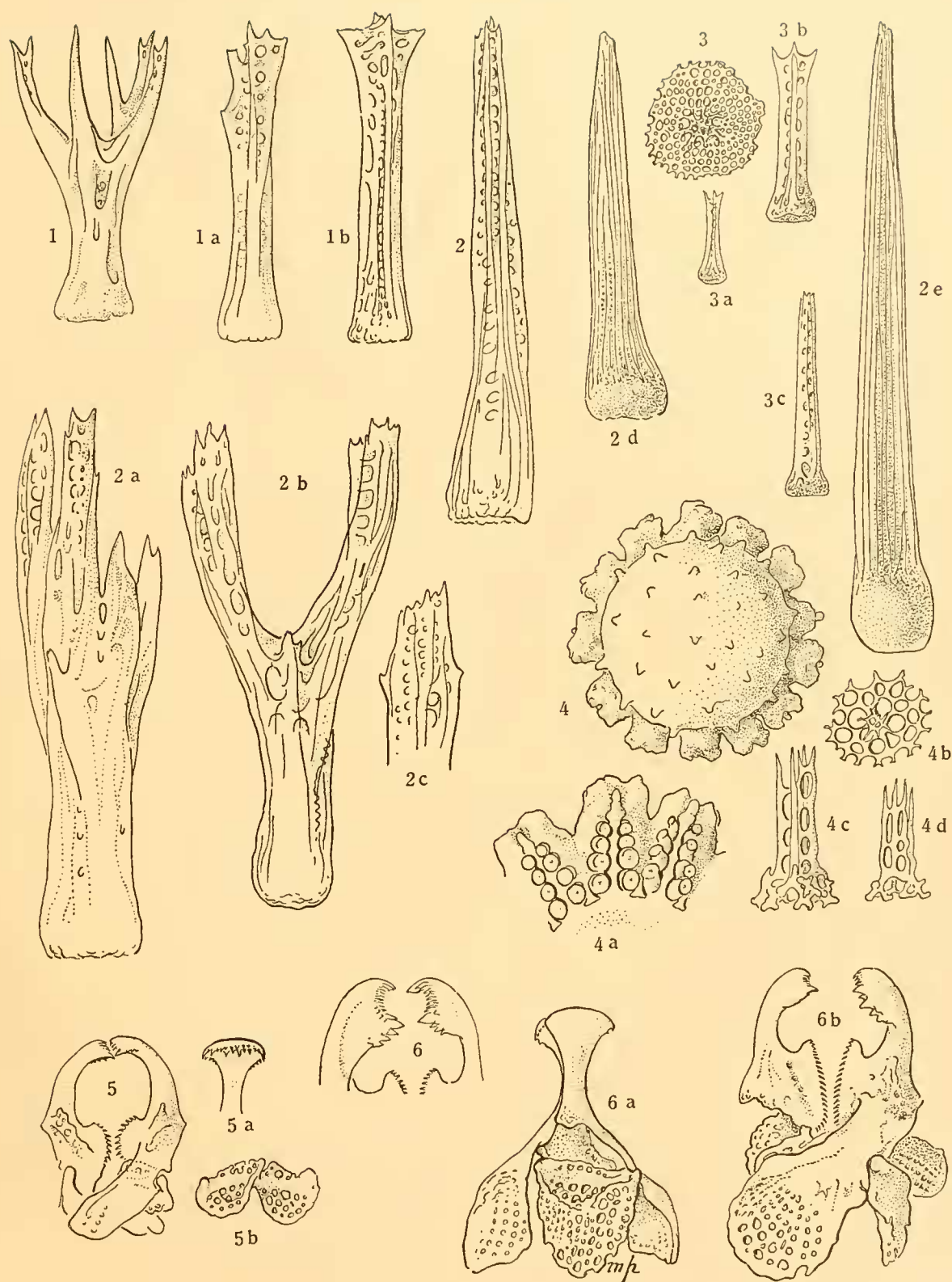


Fig. H

All figures enlarged $\times 20$, except 7 and 8 which are $\times 10$

1. *Odinella nutrix*. Actinostomial ring viewed from outside, showing an interradius and the distal face of second ambulacral and of first adambulacral plates where 2 rays have been detached. a^1 , first ambulacral plates (dorsal surface); a^2 , distal face of second ambulacral plates; ad^1 , distal, articulating face of first adambulacral plates; i , interradiial plate (odontophore); m , first pair of inferomarginal plates, closely apposed, above the first adambulacrals; p^1 , p^2 , position of first and second ambulacral pores.
2. *Brisingella pusilla* Fisher (California). Mouth-plate (z , x , y) for comparison with fig. 3. The plate is seen from the furrow face, the actinal surface being in profile below. On the left the odontophore (i), marginal (m), and first adambulacral (ad^1) are shown. In this genus the interradiial angle (on the opposite side of ad^1 and m) is defined by these plates (fig. 8); v , groove of circumoral water tube at point where the radial tube passes to right in groove r ; s , spine-bearing margin of plate; in the groove above is the circumoral nerve; x , lateral wing of plate shown in figs. 7 and 8 viewed endwise; y , shorter ventrolateral wing shown in fig. 7; z , dorsal wing (fig. 8).
3. *Odinella nutrix*. Mouth-plate viewed from furrow face with interradiial plate (i) in position. a'' , articulating surfaces of first ambulacral plate; ad'' , same of first adambulacral; p' , side of first ambulacral pore; r , groove for radial water tube; s , spine-bearing margin of plate, the deep groove above for circumoral nerve; v , groove for circumoral water tube; x , lateral wing of plate which joins that of neighbouring plate across ambulacral furrow; y , portion of plate which forms a ventrolateral wing in fig. 7; z , the dorsal extension of plate (figs. 4, 6).
4. *Odinella nutrix*. Segment of actinostomial ring viewed from the inner or oral face. On the right a pair of mouth-plates, o , is hatched to differentiate them from the first ambulacrals (a^1), one of which has been lifted out. Note x , the lateral wing of each mouth-plate for comparison with figs. 5 and 7, and crossing it, v , the groove of circumoral water canal; o' indicates position of muscles so indicated in fig. 6; z , the dorsal extension of plate which locks with the first ambulacral.
5. *Odinella nutrix*. A pair of mouth-plates seen from below. On either side is the first ambulacral plate a' , the left one is hatched; ad'' , the facet of plate with which the first adambulacral forms a muscular joint; s , spine-bearing margin; v , position of circumoral water tube; x , lateral wing which joins that of opposite side of furrow ($x-x$, fig. 4); y , portion of plate corresponding to y , fig. 7.
6. *Odinella nutrix*. Segment of actinostomial ring viewed directly from above. On right, a single first ambulacral plate is hatched. Note the broad muscular symphyses at o' , o'' directly below odontophore, i , in contrast to the same in *Brisingella* (fig. 8). These confer a high degree of flexibility to actinostomial ring. The first adambulacrals are shown in solid black beneath the second ambulacrals. The entire length of the first inferomarginals, m , is shown, whereas in fig. 1 they are greatly foreshortened; z is the dorsal extension of mouth-plate which forms a non-muscular symphysis with the first ambulacral.
7. *Brisingella pusilla*. The ventral aspect of a segment of the actinostomial ring ($\times 10$) for comparison with fig. 5. A pair of mouth-plates is dotted. The lateral extensions $x-x$ (so marked in other figures) are notable for unusual length. Above them passes the radial water tube, r ; the ventrolateral wings, Y , are not present in *Odinella*. One first ambulacral is hatched. Other letters: a^1 , a^2 , first and second ambulacrals; ad , first adambulacrals; m , pair of first inferomarginals defining the interradiial angle; p^1 , p^2 , pores of first and second tube-feet.
8. *Brisingella pusilla*. Dorsal aspect of segment of actinostomial ring for comparison with fig. 6. On right the odontophore, i , has been removed and a pair of mouth-plates dotted; behind them as much as can be seen of first adambulacrals, ad' is hatched. The lateral, x , and dorsal, z , wings of the mouth-plates o are conspicuous. Other letters as in fig. 7.
9. *Odinella nutrix*. Ventral aspect of the interradiial plate or odontophore.

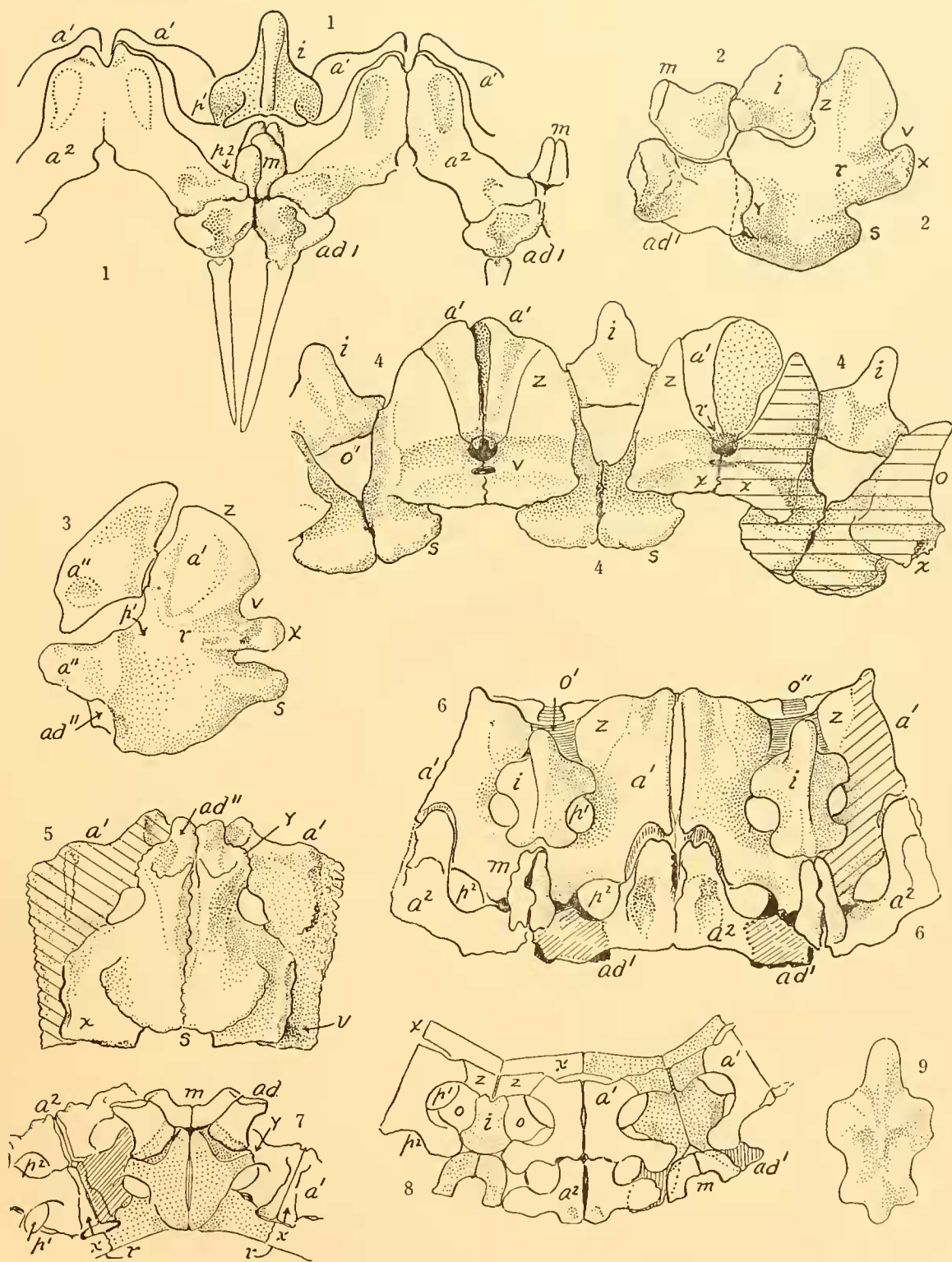


Fig. 1

1. *Anteliaster australis*, type; crossed pedicellaria, 0.4 mm. long, $\times 100$. 1*a*. St. 246. One jaw, $\times 200$; pedicellaria 0.3 mm. long. 1*b*. Paratype, inferomarginal spine, 0.5 mm., $\times 100$. 1*c*. Paratype, carinal spinelet, 0.35 mm., $\times 100$. 1*d*. Paratype, dorsolateral spinelet, 0.29 mm., $\times 100$.
2. *Labidiaster radiosus*, abactinal pedicellaria from transverse ruff at middle to ray, St. 51; length 0.6 mm., $\times 100$. 2*a*. Same from St. WS 79, R 105 mm.; length 0.65 mm., $\times 100$. 2*b*. From outer adambulacral spine, St. 51; length 0.26 mm., $\times 100$.
3. *Labidiaster annulatus*, pedicellaria from abactinal transverse ruff at about middle of ray of large specimen, St. 1955; length 1.4 mm., $\times 100$. 3*a*. Same as 3, from smaller specimen, St. 1955, length 0.9 mm., $\times 100$. 3*b*. From outer adambulacral spine, St. 1955; length 0.27 mm., $\times 100$. 3*c*. One of the small crossed pedicellariae found among the large ones, from smaller specimen, St. 1955, length 0.38 mm., $\times 100$. 3*d*. Straight pedicellaria from inner margin of mouth-plates, larger specimen, St. 1955; length 1.27 mm., $\times 50$. 3*e*. Three oral angles showing fusion of mouth-plates; from small specimen with disk diameter 22 mm., St. 371, $\times 15$. Most of the pedicellariae are omitted to show the spines more clearly; NC, neural canal roofed by joined mouth-plates.

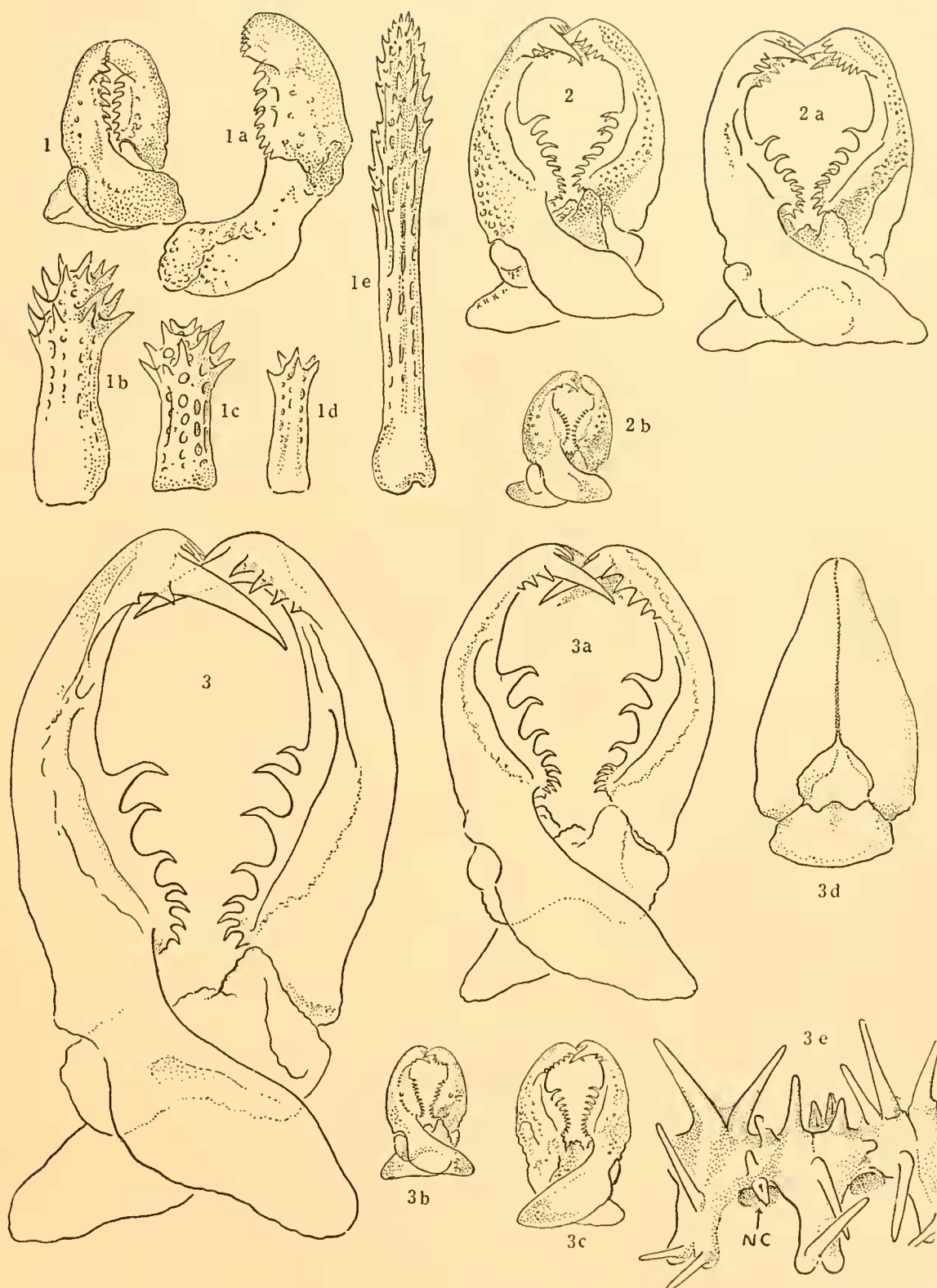


Fig. J

1. *Notasterias stolophora*, pedicellaria from carinal spine, 0.76 mm. long, $\times 100$. 1a. From same spine as fig. 1, 0.78 mm. long. 1b. From inferomarginal spine, 0.71, $\times 100$. 1c. From superomarginal spine, 0.76 mm., $\times 100$. 1d. An incompletely developed pedicellaria of the sort shown in fig. 1b, from inferomarginal spine, 0.6 mm., $\times 50$. 1e. Carinal spine and pedicellaria, $\times 25$.
2. Pedicellariae drawn to scale, $\times 10$: a, *N. armata*, carinal; b, *N. stolophora*; c, *N. bongraini*, carinal; d, e, *N. bongraini*, normal crossed ped. from inferomarginal spine.
3. *N. bongraini*, from carinal spine, length of ped. 1.87 mm., $\times 100$. 3a. From superomarginal spine, 0.62 mm., $\times 100$. The inferomarginal pedicellariae are similar and 0.37–0.5 mm. long.
4. *N. armata*, jaw of a carinal pedicellaria; whole ped. 3 mm. long, $\times 50$. 4a. Incompletely developed superomarginal ped., $\times 10$. 4b. From inferomarginal and actinal spines, 0.93 mm., $\times 50$.

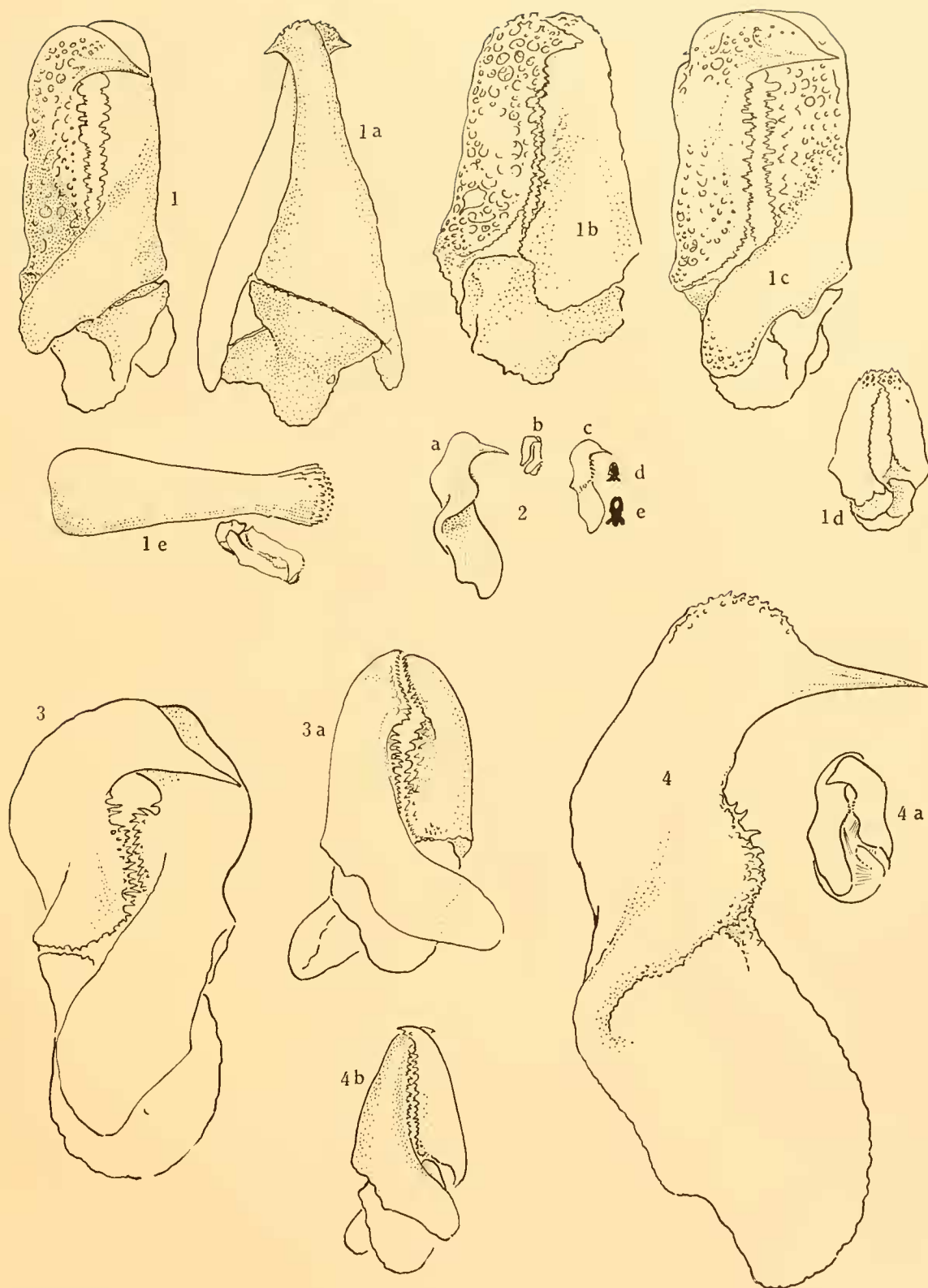


Fig. K

1. *Notasterias armata*. Skeleton of one side of ray, near base (which is to left), $\times 6$; CC, carinal series; DL, dorsolaterals; S, superomarginals; I, inferomarginals; A, actinals.
2. *Psolidaster mordax*. Typical abactinal pedicellaria, 0.9 mm., $\times 100$. 2a. Inner side of one jaw, $\times 100$. 2b. Inferomarginal pedicellaria, opposing face of a jaw, $\times 50$. 2c. Inner side of a jaw, $\times 100$. 2d. Adambulacral straight pedicellaria, 0.68 mm. long, $\times 50$. 2e. Opposing face of a jaw showing denticles, 0.5 long, $\times 100$. 2f. Back view of inferomarginal pedicellaria (0.93 mm. long) to show flaring handles and basal piece, $\times 50$. 2g. Side view of same, $\times 50$.
3. *Psolidaster mordax*. Abactinal spinelet 1.8 mm. long, $\times 50$. 3a. Two abactinal spinelets, 1 and 1.5 mm. long, $\times 50$. 3b. Portion of lateral and actinal skeleton near base of ray which is at left, $\times 10$. DL, dorso-lateral primary plates; S, superomarginals; I, inferomarginals; AD, adambulacrals.

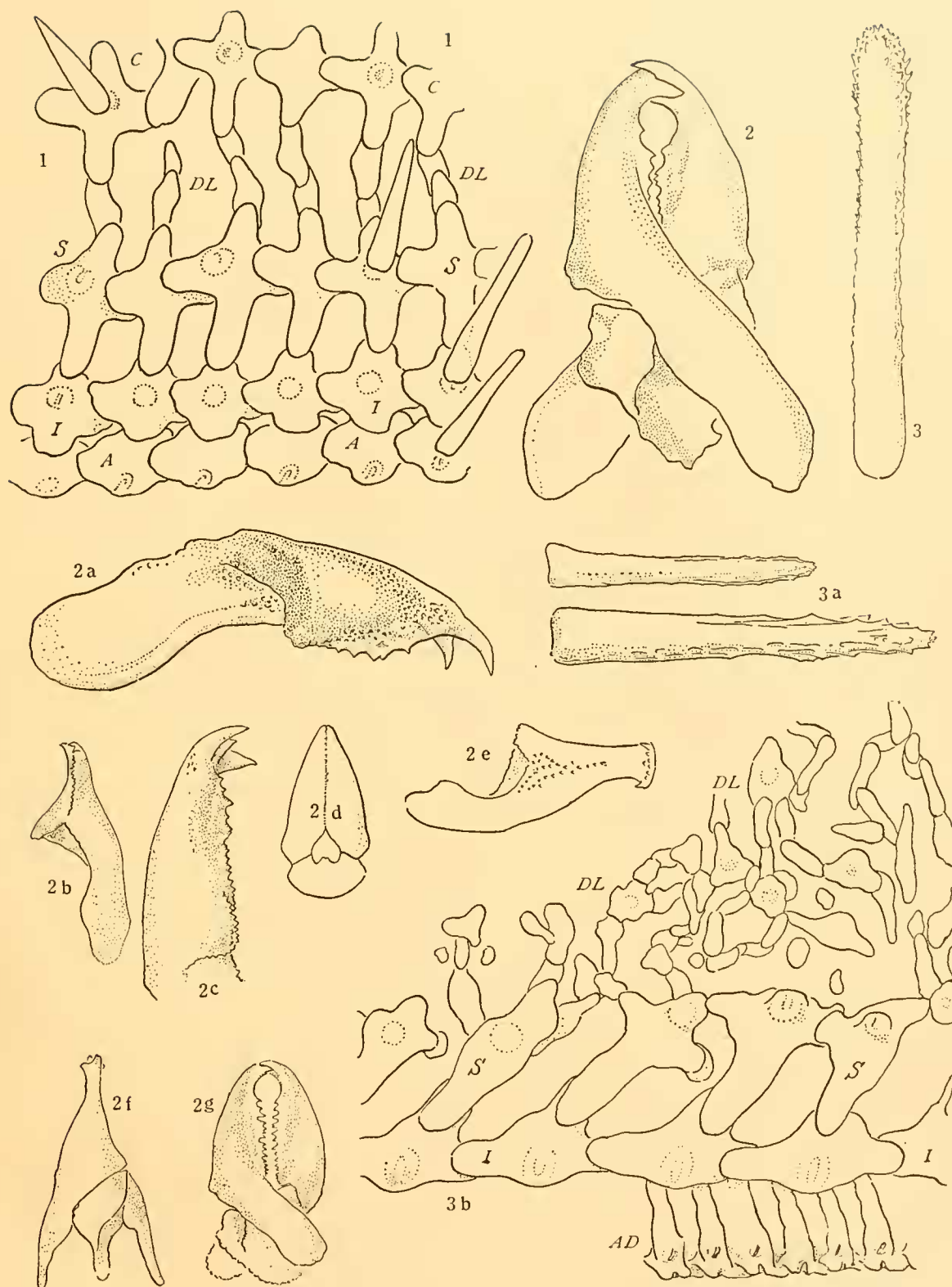


Fig. L

1. *Lethasterias australis*, jaw of inferomarginal crossed pedicellaria, $\times 200$. 1a. Carinal spine, 1.53 mm. long, $\times 25$. 1b. Dorsolateral spine, 0.85 mm., $\times 25$. 1c. Two aspects of a superomarginal spine, 1.6 mm., $\times 25$. 1d. Two inferomarginal spines, 1.45 and 1.7 mm., $\times 25$. 1e. An adambulacral spine, 1.5 mm., $\times 25$. 1f. An abactinal crossed pedicellaria, 0.3 mm., $\times 100$. 1g. A marginal crossed pedicellaria, 0.43 mm., $\times 100$.
2. *Lethasterias australis*, plan of plates of one side of ray from fifth to eleventh superomarginals, base of ray to left; C-C, carinal series; DL, dorsolaterals; S, superomarginals; I, inferomarginals.
3. *Lysasterias hemiora*, abactinal crossed pedicellaria, 0.38 mm., $\times 100$.
4. *Lysasterias heteractis*, abactinal pedicellaria, 0.46 mm., $\times 100$. 4a. Inferomarginal pedicellaria, 0.74 mm., $\times 100$. 4b. Detail of abactinal pedicellaria 0.5 mm. long.
5. *Coscinasterias calamaria*, St. 1686; abactinal crossed pedicellaria, 0.21 mm., $\times 200$. 5a, 5b. Straight pedicellariae, 0.20 and 0.30 mm., $\times 200$.

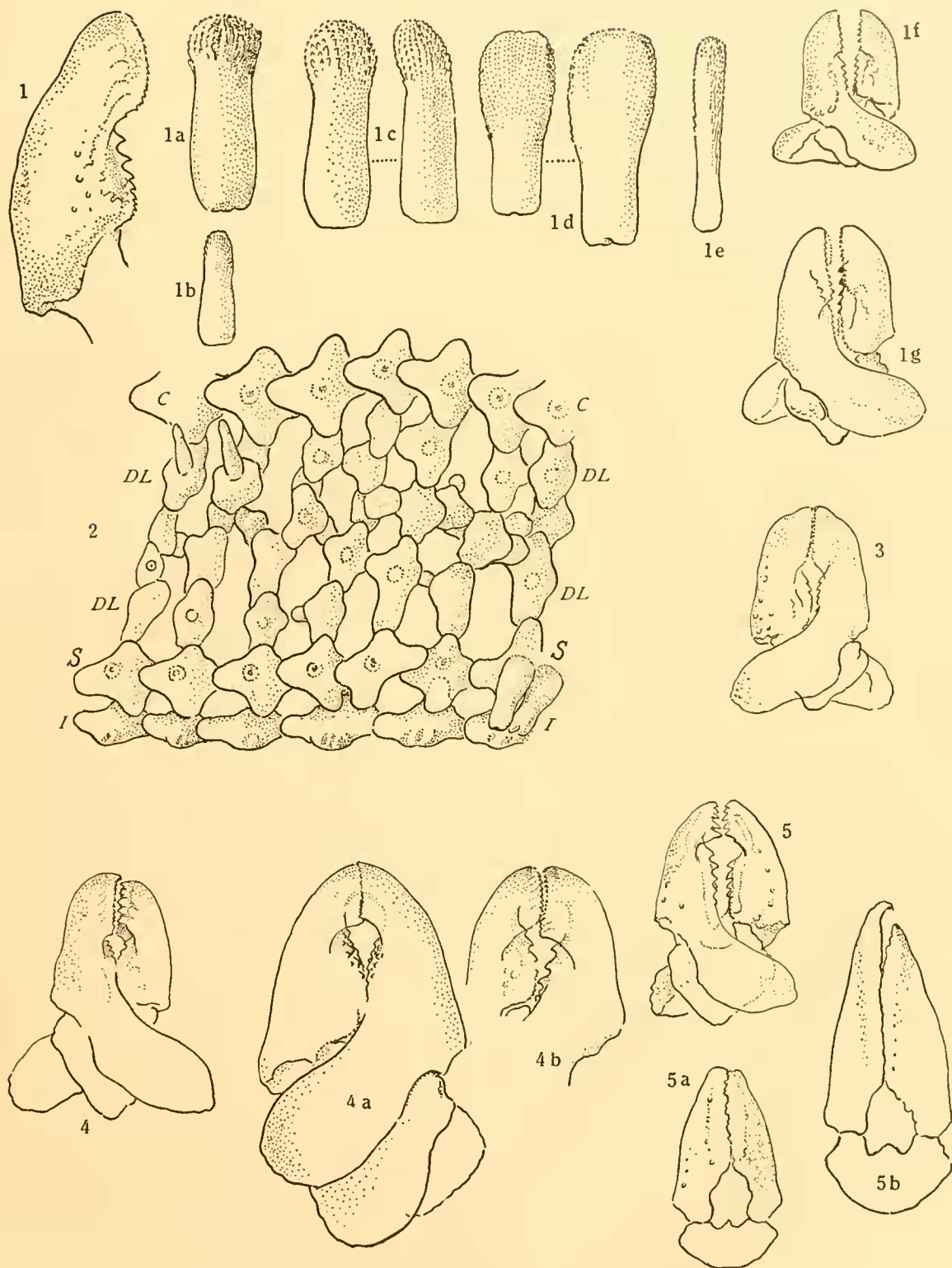


Fig. M

1. *Diplasterias octoradiata*, St. MS 6; abactinal pedicellaria, 0.43 mm., $\times 100$. 1 *a*. Profile of 2 jaws, $\times 100$. 1 *b*. A straight pedicellaria, 1.27 mm., $\times 50$. 1 *c*. Forma *eunota*, profile of 1 pedicellaria jaw.
2. *Diplasterias meridionalis*, St. MS 10, abactinal pedicellaria, 0.37 mm., $\times 100$. 2 *a*. Marginal pedicellaria, 0.52 mm., $\times 100$. 2 *b*. A straight pedicellaria in profile, and inner face of 1 jaw. 1.02 mm., $\times 50$.
3. *Diplasterias radiata*, 2 abactinal spinelets, 0.85 mm., $\times 50$. 3 *a*. Jaw of a crossed pedicellaria, $\times 200$; length range 0.27–0.3 mm. 3 *b*. Valve of a straight pedicellaria, $\times 100$.
4. *Luidia heterozona*, 2 inferomarginal plates, proximal third of ray, to show different armature of alternate plates; base of ray is to left, $\times 10$. *a*, abactinal paxilla; *ap*, actinal pedicellaria, *s*, superomarginal, fused to upper end of inferomarginal. 4 *a*. A single mouth-plate seen slightly from side, $\times 10$. *a*, apical spine; *n*, nerve; *p*, pedicellariae mentioned in text. 4 *b*. Abactinal paxilla of second longiseries, dried, $\times 30$. 4 *c*. Disk paxilla, alcoholic specimen, $\times 30$.
5. *Luidia aciculata*. Two inferomarginal plates near base of ray to show different position of spines on alternate plates, $\times 10$. Two superomarginal paxillae (*s-s*) are also shown.

